EXHIBIT 9

MTBE RELEASE SOURCE IDENTIFICATION AT MARKETING SITES

A Study Conducted for EUSA ESD by

Exxon Research & Engineering Company

3/30/99

EXHIBIT
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MTBE RELEASE SOURCE IDENTIFICATION AT MARKETING SITES
(A STUDY CONDUCTED FOR EUSA ESD)

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I. Background

a. Study Basis

In August 1998, EUSA Environmental and Safety Division (ESD) requested Exxon Research and Engineering Company to conduct a study identifying potential release sources of the gasoline additive Methyl-Tertiary-Butyl Ether (MTBE) at Exxon retail marketing sites. Interest in identifying these potential sources is important to EUSA, as well as most other U.S. petroleum marketing companies, because MTBE contamination is increasingly being found in surface and ground waters near gasoline service stations, and has been identified as a potential threat to public drinking water supply systems. By identifying the potential release sources, it is expected that all necessary and appropriate corrective measures can be taken so that accidental releases of MTBE into the subsurface environmental can be prevented.

The objective of this study was to evaluate and categorize the extent and sources of MTBE contamination in soils and ground water at Exxon retail sites. A related objective is for EUSA to use results from this study to assist industry regulatory advocacy efforts with various state and federal environmental agencies. These agencies (with the state of California most notable) are addressing growing public concerns about potential MTBE human health effects, and are enacting regulations to require significant MTBE remediation programs and possibly the elimination of its use as a gasoline additive.

b. MTBE Contamination Issues at Marketing Retail Sites

Methyl tertiary-butyl ether (MTBE) is present in gasoline as an octane enhancer (concentrations up to 9% by volume) or as an oxygenate to reduce ozone and carbon monoxide levels in air (concentrations 11-15% by volume). The presence of MTBE found in surface, ground and drinking waters has been increasing. There are several reasons why increased MTBE presence can be a concern:

- MTBE behaves differently than other gasoline constituents, i.e. it is relatively:
  - more soluble in water,
  - more volatile from product to air,
  - less volatile when dissolved in water to air
  - less likely to adsorb to soil or organic carbon
  - relatively more resistant to biodegradation.

- There is an increase in awareness since the public can easily detect its existence
  - Taste and odor detectable threshold levels are in the ppb ranges (15-180 ppb)

- Small leaks of gasoline (1 teaspoon) can translate into MTBE ground water concentrations above the taste and odor detectable threshold levels. A standard

Underground Storage Tank (UST) leak detection threshold of 0.01 gallons per hour converts into 7.5 teaspoons/hour. (See Figure I-1 for corresponding MTBE concentrations levels).

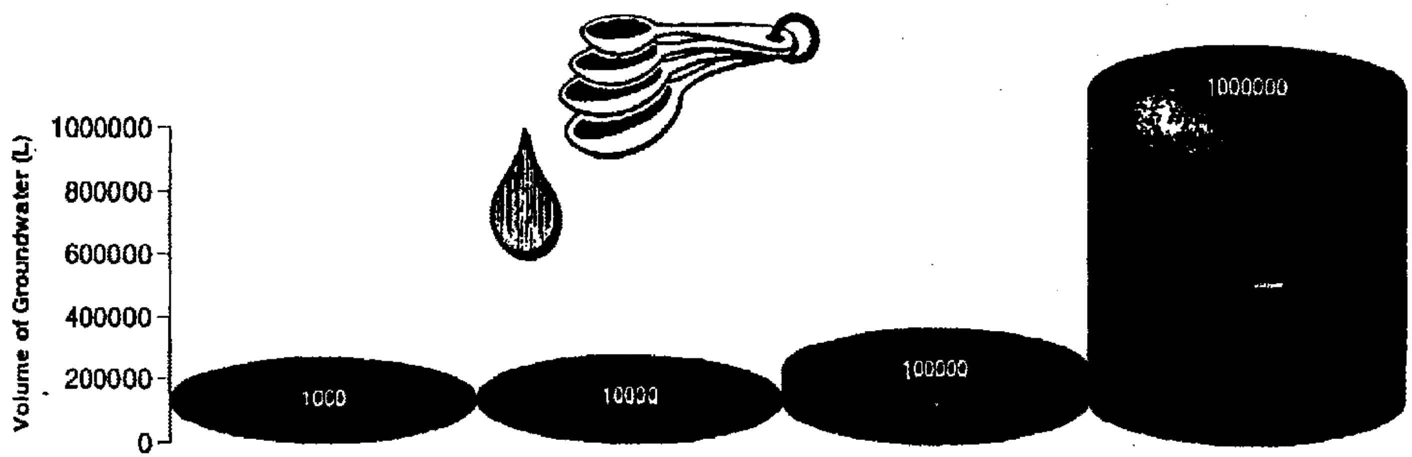
c. Public and Regulatory Agency Concerns

The increase in the presence of MTBE found in surface, ground and drinking waters has generated public, government regulatory agency, and industry concerns. With uncertain human health and environmental potential effects, public concerns about the need for control or elimination of MTBE in gasoline has accelerated. California has been the most proactive with this issue, with other states rapidly catching up. MTBE litigation for EUSA and the petroleum industry has increased. For example the "Californian's for a Better Environment (CBE)" recently filed a product liability suit against Exxon, ARCO, Mobil, Shell, et. al. Government regulatory agency concerns have also heightened. In fact, the scope of site investigation programs has been expanded and a more conservative cleanup criteria for ground water (1-5ppb) is being considered in some states. Many questions are being posed by regulators, including:

- What is the potential carcinogenicity of MTBE?
- Where is the MTBE coming from? Is MTBE compatible with all the materials it comes in contact with? What is its behavior in soil and ground water?
- Should MTBE be banned and replaced with alternative oxygenates or alcohols?
- With such a high concentration in the gasoline and such a low cleanup threshold limit, can this issue be managed?

Figure I-1: Impact of Small Releases

1 Teaspoon of Gasoline ~ 5 ml
Assume 11.5 vol. % MTBE, 1.5 vol. % Benzene
Potential Impact on Groundwater a Function of Groundwater Volume



Concentrations:

MTBE (ppb)	413	41	4	0.4
Benzene (ppb)	64	6.4	0.6	0.06

d. Study Workscope

At the project kick-off meeting between ESD and ER&E held July 28, 1998 in EUSA's Houston headquarters office, the following activities were agreed to as part of the study workscope:

- Conduct literature and research reviews on MTBE source identification, with focus on retail marketing facilities
- Perform selective reviews of MTBE ground water contamination data at EUSA service stations in New Jersey and California
- Identify gaps in existing data
- Conduct a preliminary assessment of MTBE material compatibility issues
- Document potential sources of MTBE contamination at marketing facilities, and develop initial quantification of magnitude and significance

II. Executive Summary

Data from selected EUSA Service Stations with MTBE contaminated ground water was reviewed. In New Jersey data from 38 sites was reviewed and in California, 71 sites. The range of maximum MTBE concentrations found in the ground water data was 2 to 1,040,000 ppb. The data fit within the envelope of similar MTBE data analyses reported by others (Chevron, Lawrence Livermore National Labs, University of Texas Studies, etc). Connection to specific leak sources from the data made available by EUSA is not readily apparent.

Materials of construction were evaluated, and are considered largely compatible with MTBE service. For tanks and piping, metals and fiberglass are resistant to MTBE-blended gasolines. MTBE should not enhance corrosion or permeation through these materials. Manufacturer's data on flexible piping indicate that flexible piping should be compatible; however, less data is available to confirm the manufacturer's claims. For seals, several elastomers and plastics have shown resistance (based on primarily short-term exposure tests) to MTBE blended gasolines. There are, however, elastomers and plastics which have shown poor compatibility with MTBE. These can have the same appearance as the specified seal and can therefore easily be inadvertently installed. Post mortem analysis would be required to identify this problem should it be the source of a leak. With regards to materials compatibility of vapor recovery systems, vapors are not as aggressive as liquid. MTBE-enriched condensate is possible with high vapor pressure, although there is limited documentation of this occurring.

Potential release sources are identified, and include: auto refueling, filling of underground storage tanks (USTs), and UST system releases. Whether a service station is self or full service, repeated small releases during auto refueling have the potential to impact soil and/or ground water. The potential for subsurface contamination is minimized by evaporation, but can be increased in the area where leaks or spills occur if the pavement is cracked. Possible preventive steps include installing liners under service areas or sealing cracks as soon as possible. When filling the USTs, small releases can occur at the connections below grade. Overfill is minimized with three spill/overfill protection components: the submerged turbine pump (STP) sump on top of the tank (designed to be water tight), overfill protection with the use of a ball float which seals off the top of the tank preventing overfill; and the spill containment buckets which are designed to be gasoline tight plastic boots. Connections and seals are more likely to be sources of leaks in the UST system than the piping and tanks. System tightness integrity testing is performed; however, the threshold limits do not detect all leaks (0.01-0.1gallons per hour). Discussions with Crompco Corporation, a company who performs leak tightness tests, indicate that the best available equipment is certified down to 0.05 gallons per hour.

The selection of appropriate laboratory analytical methods to measure MTBE concentrations in ground water is crucial to reducing the potential for getting false positive readings. Several studies (Shell, Chevron, Lawrence Livermore National

laboratory) have evaluated the appropriateness of existing EPA MTBE test methods. EPA Method 8020, most frequently used for ground water analysis, has been found to overestimate, or indicate false positive readings, when used on samples containing significant levels of other gasoline components. Recent studies indicate this problem becomes more severe for samples containing TPH and/or BTEX concentrations greater than 1,000 μg/L and MTBE concentrations less than 1,000 μg/L. Use of EPA Methods 8240/8260 has been found to eliminate the occurrence of false positives. Confirmatory testing of ground water samples analyzed by EPA Method 8020 is recommended, using Method 8260, when TPH or BTEX concentrations in ground water samples are greater than 1,000 μg/L.

III. Research and Literature Review

a. Related Research Organizations

A review of literature and research activities on MTBE contamination prevention and source identification was conducted. Several organizations have developed teams to address issues associated with MTBE. The major organizations are listed below; research interests represent a range from health issues to fate and transport to source identification. The first three groups are seen as the most valuable resources in terms of focus on service station issues and source identification, and therefore warrant longer term monitoring and/or participation (initial Exxon involvement indicated in brackets):

- Western States Petroleum Association (WSPA) - *[EUSA involvement]*
  - Source/Protection Research Partnership
- American Petroleum Institute (API) - *[EUSA and ER&E involvement]*
  - Soil / Ground water Technical Committee MTBE Research Group
  - Gasoline and MTBE Source Identification Workgroup
- Petroleum Environmental Research Forum (PERF) - *[ER&E involvement]*
  - MTBE Source Identification and Contamination Prevention Project Proposal
- California Governor's UST Panel (Three teams):
  - Team 1: Materials Compatibility
  - Team 2: Analysis of Recent Releases ('98 Compliant Systems)
  - Team 3: Analysis of UST System Failures Leading to MTBE Contamination
- Oxygenated Fuels Association (OFA) Research Group
- Lawrence Livermore National Laboratory (LLNL)
- University of California - Davis (UCD)
  - Integrated MTBE Research Program
- Federal / State / Local MTBE Research Groups
  - EPA Studies, Santa Clara Valley Water District, USGS Characterization Studies
- EPA Blue Ribbon MTBE Panel
  - Includes Experts from Government, Scientific, Fuels Industry (Sun, API, ARCO)
  - Panel to Report to EPA Mid-Year 1999 on Findings and Recommendations, including:
    - Study of Causes of Ground water and Drinking Water Contamination
    - Evaluation of Prevention and Cleanup Technologies for Soil and Water

Many of these groups have been recently formed and are therefore still studying MTBE issues. Significant publications of findings on source identification from these groups (particularly the API and California Governor's UST Panel Teams) are expected in 1999. The API gasoline and MTBE Source Identification Workgroup is developing a matrix of potential sources and their cause. A preliminary version of the matrix include whether or not gasoline and MTBE sources are an operational issue (can be controlled by the operator), likelihood of occurrence, mechanism of impact (direct contact, diffusion), quantity expected, whether or not it is readily or automatically detectable/measurable, method of detection, and whether or not it would be captured by regulatory leak detection systems.

b. Literature Search Review & Highlights

As the literature search was conducted, four areas of focus were identified: analytical issues, compatibility, prevalence of MTBE contamination, and sources. A listing of reviewed references is attached as an Appendix to this report.

A brief summary of the most significant findings from the literature review follows.

- *Analytical Issues:* Researchers at Shell, Chevron, and LLNL have documented numerous cases of false positives as the result of the analytical procedure used to test for MTBE. This issue is further described in section IV-b of this report, where available literature is compared to data from Exxon stations.

- *Material compatibility:* Literature surveys of recent work studying MTBE compatibility with components of UST systems have been developed by Couch and Young at the University of California-Davis, and Davidson of Alpine Environmental. These provide good overviews of the available literature in this area , and form the basis for a large portion of section V-d of this report. Additional literature will be available from the California Governor's Team 1 report due in 1999. Preliminary results from the report indicate that MTBE is generally compatible with UST system components in the liquid phase. Not enough information was available to determine if there were compatibility problems with the vapor phase, at this time. The draft report also indicates that consistent performance criteria for UST product testing may be an issue. A review of Exxon Engineering literature was also conducted and identified several reports from the 1990's focused on MTBE compatibility with metals, fiberglass, plastics, and elastomers. Results are discussed in section V-d.

- *Prevalence of MTBE Contamination:* Researchers at LLNL, the University of Texas, and Chevron have conducted analyses of data from UST sites in an attempt to quantify the levels of contamination seen across geographic boundaries and geological conditions. This data, along with similar data from Exxon sites, is summarized in sections IV of this report. Researchers at USGS and the Maine

Department of Health have conducted broader surveys examining the prevalence of MTBE in general, including: surface waters, storm waters, and drinking waters.

- *Potential Sources:* Relatively little work has been performed to quantify sources of gasoline or MTBE to the environment. Recent studies by Young (UC-Davis), as part of the California Governor's Team 3 report, have tried to evaluate where releases from UST systems are occurring by examining databases of site records and UST facility inspections. The results of this work is discussed and summarized in section V-b. Governor's Team 2 focused on upgraded facilities. Preliminary results (second draft, 12/14/98) indicate that there is evidence of leaks from newer systems; however, it is not clear whether there is enough information to indicate if the results are statistically significant. Most releases from service station sites meeting the 1998 standards were the result of improper installation, operation or maintenance.

Nearly all of the researchers listed above are expected to continue investigating MTBE source identification and related issues. As such, continued monitoring of their activities is recommended to keep informed of the latest advances in this area.

IV. Analysis of EUSA MTBE Ground Water Contamination Data

Ground water monitoring data from retail sites in California and New Jersey were reviewed. The purpose of this review was to evaluate and compare Exxon's data with other industry data, determine if sources of MTBE releases could be identified, and identify gaps in existing data.

a. Statistical Evaluation of Selected Sites from California and New Jersey

California Data

Data from 71 service stations in Northern California with 2Q/3Q '98 monitoring reports were analyzed. MTBE was analyzed using EPA Method 8020 and in some cases EPA Method 8240 or 8260. Assuming the detection limit for sites that reported non-detect, the maximum MTBE concentration (8020) reported range was 2 ppb to 380,000 ppb with an average concentration of approximately 39,500 ppb. In addition to maximum MTBE concentration, a table containing the corresponding BTEX concentration, distance from the monitoring well to the nearest tank, depth to the ground water, maximum BTEX concentration, number of wells with concentrations greater than 1000 ppb MTBE, total number of wells, soil vapor extraction (SVE) system, and NAPL presence was developed to summarize the California data and is included in the Appendix. Figure IV-1 shows a comparison of the Exxon data with industry data reported in other studies. As the chart indicates the percentage of operating sites with maximum MTBE concentrations greater than 10,000 ppb ranges from 10 to 38%.

Many other studies (LLNL/Happel, 1998, and Buscheck, 1997), report a poor correlation between the MTBE concentration with its corresponding BTEX concentration. The Exxon data is consistent with these industry reports. See Figure IV-2.

New Jersey Data

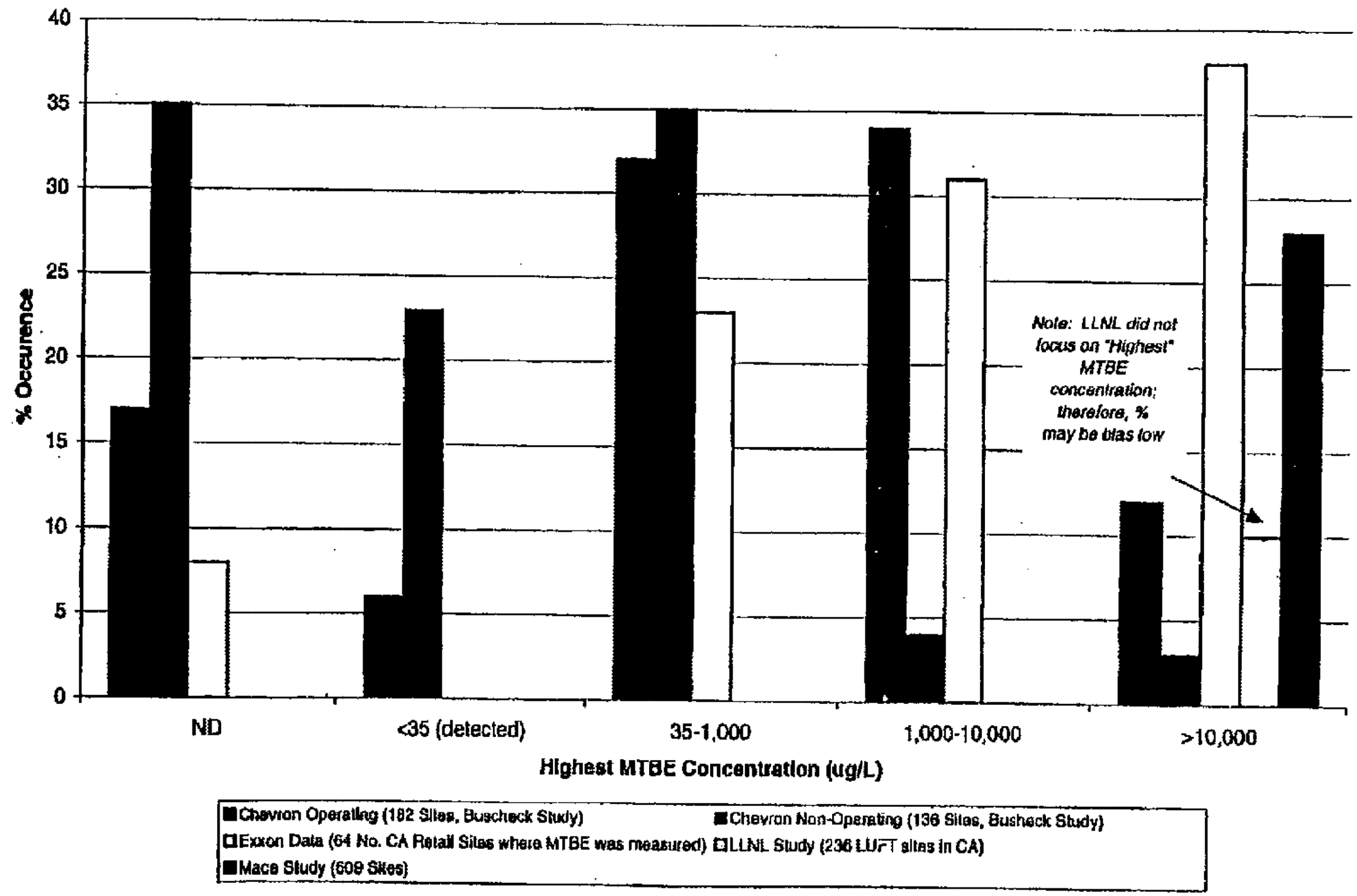
The New Jersey data are based on sites with at least one MTBE hit over 10,000 ppb out of 215 sites with environmental presence. The method for MTBE analysis varied; the majority of data is from EPA Test Method 8020, with some data from 8260. However, in the reports, the analytical method used for individual data points is not identified, therefore, all data are treated equally.

The MTBE concentrations for the New Jersey data has a range of 15,000 ppb to 1,040,000 ppb, with an average concentration of approximately 156,000 ppb. In addition to the MTBE concentrations, a table containing the corresponding BTEX concentrations, distance from the monitoring well to the nearest tank, depth to the ground water, maximum BTEX concentration, was developed to summarize the New Jersey data, and is also included in the Appendix.

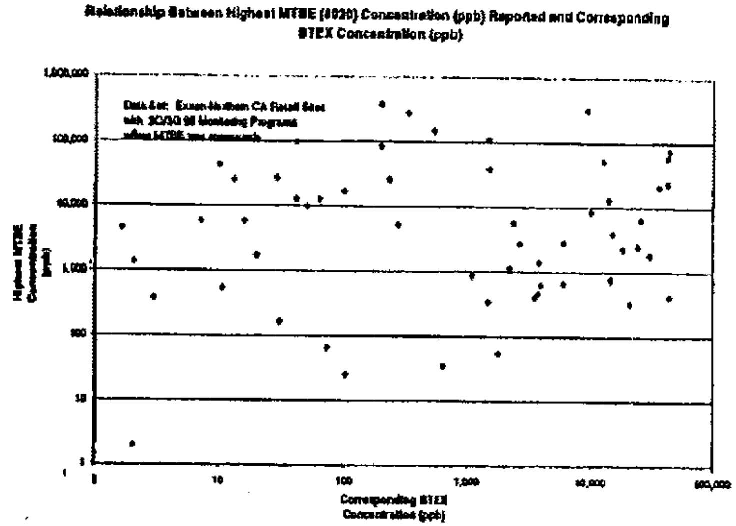
Determination if Data Can Identify Sources

Unfortunately, identification of sources of releases using the available New Jersey or California data is not possible. MTBE concentration in ground water samples is a function of many variables including: site geology, biodegradation, elapsed time from release into the ground, hydraulic conductivity, soil type, ground water hydrology, ground water depth , distance to the tank, and perhaps many more. Since the only information available from the Exxon data provided, was the distance from the monitoring well to the tank and the ground water depth, no meaningful correlations could be developed.

Figure IV-1: Comparison of Exxon Data to Other Industry Studies



Exxon Research and Engineering, Co. Confidential



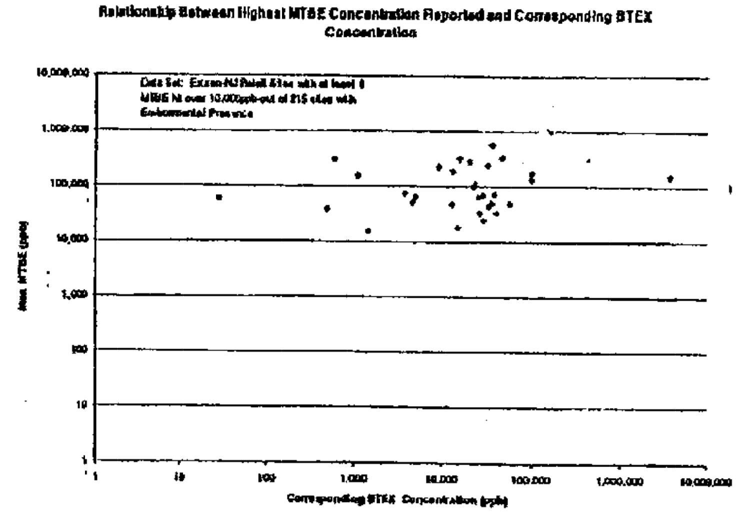
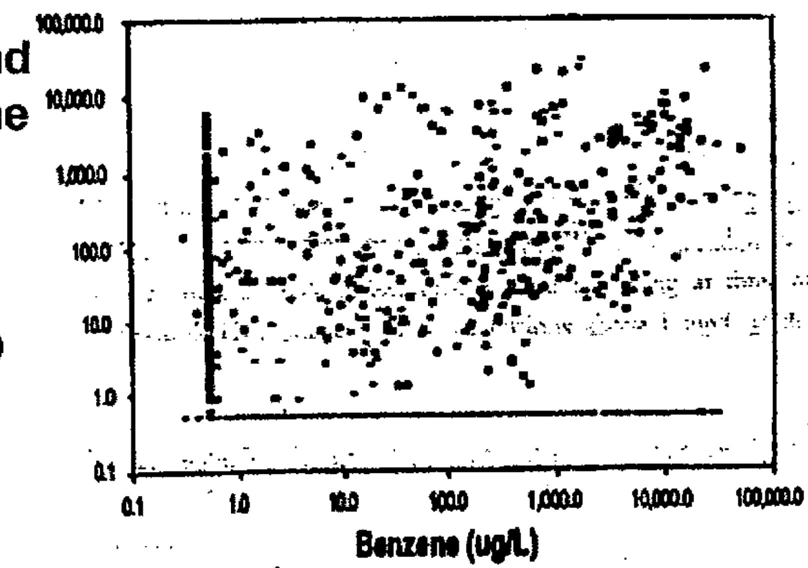


Figure IV-2

Highest MTBE Concentration and Corresponding BTEX or Benzene Concentration

Top Left: Exxon Northern California Data
Top Right: Exxon New Jersey Data
Bottom Right: Industry Study (Buscheck, 11/97)



Identification of Data Gaps

Several gaps in the data were identified. These include information available from tank and line tightness test d ıta, maintenance and construction files, and other quarterly sampling and monitoring events. As previously mentioned, the only available data for California was for those sites with 2Q/3Q 1998 monitoring programs. The New Jersey data only include data with MTBE concentrations greater than 10,000 ppb.

b. Analytical Testing Issues

The accuracy of EPA test methods for the analysis of MTBE has been the subject of debate in recent years. Several studies have looked at the appropriateness of the existing EPA methods (LLNL/Happel 1996, 1998, California EPA 1998, California Regional Water Quality Control Board (RWQCB) 1997, Buscheck 1997, Hartman 1997). The following are the most commonly used methods for analysis of MTBE: EPA 8020A and EPA 8240 or 8260.

EPA 8020 is the most commonly used method and utilizes gas chromatography (GC) with a photo-ionization detector (PID). This method, while effective for samples contaminated either with gasoline or MTBE, can encounter problems with samples containing MTBE with elevated levels of other gasoline components. EPA 8240 and 8260 methods rely on a GC separation followed by a mass spectrometer detection (MS) that is capable of higher identification accuracy than the PID.

The problem encountered by EPA 8020 is caused by a co-elution from the GC of MTBE with some alkane components of gasoline, rendering them difficult to distinguish (Hartman, 1998). TPH levels ranging from 500 ppb on up have been shown to cause some degree of interference, with greater interference at higher TPH concentrations (Buscheck, 1997; Happel 1998; CA EPA 1998). Typically, this interference is manifested as a false positive, defined as a non-detected (ND) measurement using GC/MS which follows a detection of MTBE using GC/PID, where both analytical methods were

performed on a split ground water sample. LLNL and Chevron data are summarized in the Table 1 below to indicate the potential magnitude of this problem.

Table 1: False Positive Data Using Method EPA 8020

Source	TPH level (µg/L)	MTBE Concentration EPA 8020	# samples	# false positives	% false positives
LLNL, 1996/8.	<1,000	All	280	0	0
	>1,000	< 100 µg/L	33	1	3
		> 100 µg/L	111	16	14
Chevron, 1997	<1,000	< 1,000 µg/L	18	2	11
		> 1,000 µg/L	4	0	0
	>1,000	< 1,000 µg/L	33	18	55
		> 1,000 µg/L	15	2	13

The Chevron data above suggest confirmation by GC/MS is most critical for samples with TPH >1,000 µg/L and MTBE <1,000 µg/L. Others recommend using 8020, with 8240 or 8260 for general confirmatory sampling for MTBE (Shell report in California EPA 1998, Hartman 1998). The California EPA now requires the use of EPA 8260 for MTBE analysis (California Regional Water Quality Control Board (RWQCB) 1997). For a summary of all ground water cleanup criteria and required methods for hydrocarbon-impacted sites for each of the 50 states, see Judge, et al. (1998).

In addition to producing false positive readings, EPA 8020 can also produce over-estimations of MTBE levels in ground water. Data from Exxon service stations in California were analyzed to determine the highest MTBE ground water concentrations at 70 sites. For 17 of these sites, the highest reading was measured with both 8020 and 8240 and 8260. For 8 of these 17 (47%) readings, MTBE concentrations were overestimated by method 8020, by factors ranging from 1.09 to 100. The data is further summarized in Table 2.

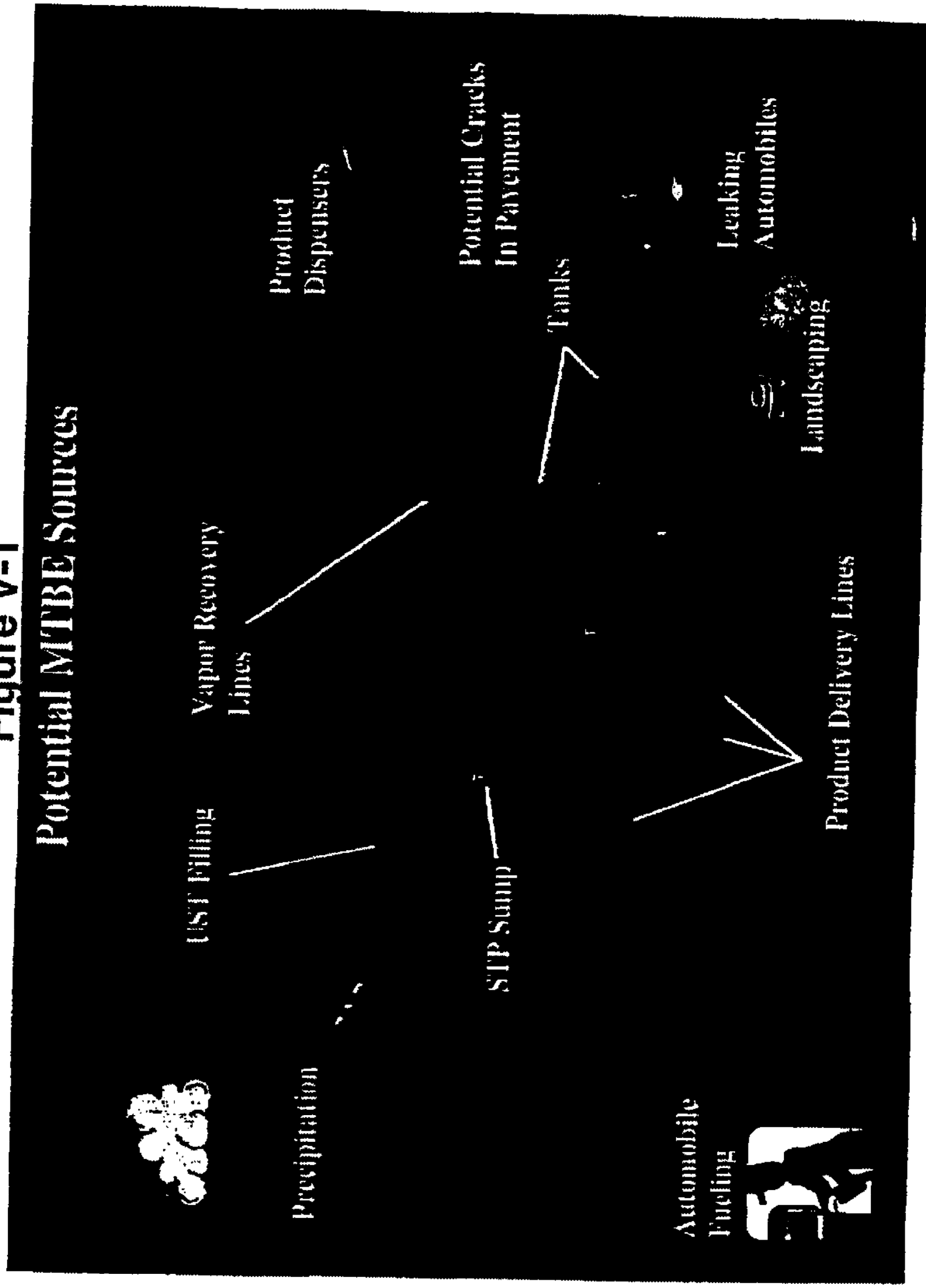
Table 2: Summary of Ground water MTBE Concentration Over-estimations

Source	BTEX level (µg/L)	MTBE Concentration EPA 8020	# samples	# over-estimated by 8020	% over-estimated
Exxon, 1998	<1,000.	< 1,000 µg/L	1	0	0
		> 1,000 µg/L	7	2	28
	>1,000	< 1,000 µg/L	3	3	100
		> 1,000 µg/L	5	3	60

Note: One sample did not test for BTEX.

Although the data set is smaller than the Chevron study, these data show the same trend as the Chevron data and therefore, confirmation testing of high MTBE readings using 8240 or 8260 is highly recommended, particularly for samples with BTEX concentrations greater than 1,000 µg/L BTEX.

Figure V-1



Adopted from U.S.EPA Station Drawing, Draft 02/09/99

V. Potential Release Sources

Figure V-1 shows a conceptual model of potential release sources for a typical four tank retail station.

a. Retail Site Potential Point and Non-Point Sources

There are many circumstances that can lead to a release of MTBE to the environment. Those expected at marketing locations are illustrated in the service station pictorial and are listed below. They consist of both point and non-point sources. Table 3 below describes these sources and their potential origin. This section contains an overview of possible sources, a discussion of material compatibility issues and an analysis of literature data on some of the point sources. Also, some sources are within the control of the retail sites, while others are outside of their control. This section concludes with a preliminary table of controllable and non-controllable sources, shown in Table 4.

Table 3: Potential Sources of MTBE Ground water Contamination

POINT SOURCES	POTENTIAL ORIGIN	
LEAKING TANKS - Underground Fuel Tanks - Above ground storage tanks - Farm tanks	- Small impact fractures in the tank - Weakening of tank integrity caused by striking of the tank bottom by the gauge sticks used to measure liquid levels. However, the use of striker plates has greatly minimized this occurrence. - Corrosion in facilities that have not be upgraded *(Corrosion in not suspected in upgraded facilities-Current materials and designs provide adequate protection to underground storage tanks and piping lines against corrosion)*	
LEAKING PIPES - UST piping (product and/or vapor recovery lines (1)) - Petroleum Fuel Pipelines	- Failure can be the result of material incompatibility or improper workmanship at the time of installation. - Failure could potential develop overtime as a result of pressure on the joints (e.g. soil pressure from settling soil)	
LEAKING CONNECTIONS/JOINTS/SEALS - UST piping (product and/or vapor recovery lines(1)) - Petroleum Fuel Pipelines	- Failure could be the result of material incompatibility or improper workmanship at the time of installation. - Failure could potentially develop overtime as a result of pressure on the joints (e.g. soil pressure from settling soil)	
NON-POINT SOURCES		
Surface Spills (1) that find their way to the ground water through cracked payment, etc.	Auto refueling Overfilling tanks during delivery Old/Abandoned Vehicles	Car/Truck Accidents Lawn mower Pump Maintenance
Atmospheric Deposition	MTBE is volatile and will be released to the atmosphere whenever MTBE enhanced gasoline vapors are released. Research has shown that concentrations from this non-point source can lead to contaminated precipitation and resulting ground water MTBE concentrations ranging up to 2-20 μg/L (API, 1997, Squillace, et al., 1995 & 1998).	

(1) EUSA Marketing believes that these sources are probably underrated.

Several of the sources shown in Table I are described in further detail below.

Point Sources

UST System Releases

- Connections and Seals are More Likely Sources than the Piping and Tanks
- System Integrity Testing can be Performed, however Thresholds Limit Ability to Detect All Leaks (0.01 - 0.1 GALLONS PER HOUR)
- Testing of Vapor Recovery Systems is not Always Performed
- Potential Minimized by Comprehensive Testing Program; Increased by Poor Installation

Tanks and Piping. Current materials and designs provide adequate protection to underground storage tanks and piping lines against corrosion. While corrosion of tanks used to be more commonplace, it is rarely encountered today at facilities with up-dated tankage (Moreau, 1997). While corrosion can be caused by aggressive soil conditions, historically, it has often been linked to weakening of tank integrity caused by striking of the tank bottom by the gauge sticks used to measure liquid levels. The use of striker plates has greatly minimized the occurrence of tank leakage caused by gauging activities. Tank and piping (line) testing is required by federal and state law to ensure the integrity of UST systems. However, while testing is required and leakage through tank or piping walls is very unlikely, leaks at the connections to the tank are possible. Figure I-1 illustrates how even a very small leak, one that would fall well below leak testing thresholds, can lead to significant contamination of soil and/or ground water. Small leaks may result from poor construction and installation of the system or may develop over time as the result of pressure on the joints. Best available equipment for leak testing is only certified down to 0.05 gallons per hour and not much more advancement is expected according to Crompco Corporation, a tightness test vendor.

UST Connections/Joints/Seals (see also Section V-e Material Compatibility Issues). The joints and connections of UST systems are the most likely parts of a UST to experience a failure. Failure can be the result of material incompatibility or poor workmanship at the time of installation. Line testing may be able to identify some connection/seal failure, however, some may fall below the accuracy limits of available tests.

Filling of USTs - Gasoline Delivery

- Small Releases, Connections Below Grade - Direct Pathway to Soil and/or Ground water
- Potential Minimized by Spill Containment Buckets
- Potential for leaks in fill lines for remote fills

The action of filling USTs presents an opportunity where human error can lead to release of gasoline to the environment. While releases of large quantities of gasoline are very unlikely, the release of small quantities during connection, filling, and disconnection are quite possible. Some tank experts feel this is one of the most underrated and overlooked sources of contamination (Rizzo, et al., 1998). Spills that occur during the filling of storage tanks can be more significant than comparable spills that might occur during the filling of an automobile. For UST filling, any contaminant that is released has a more accessible route to soil and ground water since tank connections are typically below grade. Thus potential mitigation of a release by evaporation is lessened. Spill containment buckets exist at most sites to minimize the extent of release should a spill occur. Additional overfill protection is provided by STP sumps on top of the tanks, designed to be water tight, and overfill protection via a ball float that seals off the top of the tank preventing overfill.

Remote fills have the potential to be a source for release as they have more connections and elbows than a standard fill. Additionally, the testing of the remote fill piping is often difficult or impossible due to system design. EUSA work in New Jersey in 1999 is examining the significance of remote fills as well as other release sources at sites with high levels of sustained MTBE contamination (>10,000ppb).

Pump Maintenance / Other Equipment

- Possibility of Repeated Small Releases
- Releases are Above Ground and More Controllable

There are potentially numerous small leak sources within the product dispenser and its housing. These include: product filters, meters, and flex connections. These and a number of equipment and maintenance related issues are being considered by the API Gasoline Source Identification Workgroup. Magnitude and significance of these releases will be estimated for a typical service station.

Non-Point Sources

Auto Refueling (self or full service)

- Repeated Small Releases have Potential to Impact Soil and/or Ground water
- Potential Minimized by Evaporation; Increased by Cracked Pavement

The process of refueling automobiles at service stations can lead to repeated releases of small quantities of gasoline. The volume of gasoline which drips or spills during refueling is typically very small and it is likely that the vast majority of spillage falls upon the pavement and evaporates before entering the subsurface. However, it is possible that some gasoline can drip/spill onto cracked pavement and thus have the opportunity to enter the soil and/or ground water. Discussions with EUSA Marketing environmental staff indicate that this source of contamination may be significantly underrated. Design of the service station, i.e., sloping of the concrete and the placement

of monitoring wells at low points in the pavement, can influence the effect of these small releases.

Atmospheric Deposition

- MTBE has been Detected in Stormwater and Surface Water
- Maximum MTBE Expected in Precipitation Approximately 2 ppb (Partitioning of MTBE from Atmosphere to Precipitation is Greater in Winter - Due to Temperature Effects and Increased MTBE Usage)
- Potential Minimized by Limiting Vapor Release; May be higher in areas of heavy MTBE usage and MTBE Production

During refueling and loading operations, releases of gasoline vapors to the atmosphere can be minimized, but not completely avoided. MTBE is volatile and will be released to the atmosphere whenever MTBE-blended gasoline vapors are released. Concern has been raised regarding the potential of released MTBE vapor to partition into precipitation and redeposit on the ground, possibly leading to the contamination of soil, surface water, and ground water. MTBE does have a strong affinity for water and some partitioning is likely to occur. Research has shown that concentrations from this non-point sources can lead to ground water MTBE concentrations upto 2-10 µg/L (API, 1997, Squillace, et al., 1995 & 1998). While the exact impact of atmospheric washout on ground water will depend on several factors, including runoff, depth to ground water, etc., it should be recognized as a potential source of "background" contamination. Squillace, et al. (1998) stress that elevated concentrations of MTBE in the air immediately surrounding local sources (e.g. highways, gasoline stations, parking garages, or refineries) would result in increased concentrations in local precipitation when averaged over months to years. No focused studies have been performed to further investigate this phenomenon.

Landscaping

- Potential Source of Periodic Small Releases
- Likely non-Exxon Personnel Conducting Activity

The landscaping activities around a service station may be an unexpected source of small MTBE releases. The fueling of motorized equipment (lawn mowers, edging equipment, etc.), if performed improperly, can lead to the release of small quantities of gasoline to grassy areas, where it can easy enter the soil and possibly ground water. (Reference University of Maine)

Automobiles / Accidents

- Older Automobiles may have Leaking Gasoline Tanks leading to Intermittent Small Releases over a Long Time-Frame
- Car Accidents can Cause Significant Release One-Time Releases

While these sources are expected to have a very low probability of occurrence, they should not be neglected as potential sources of MTBE release. In at least one case, litigation has been filed in Maine due to the contamination of a private drinking water well as the result of a nearby automobile accident.

b. Analysis of Industry Source Data for Service Stations

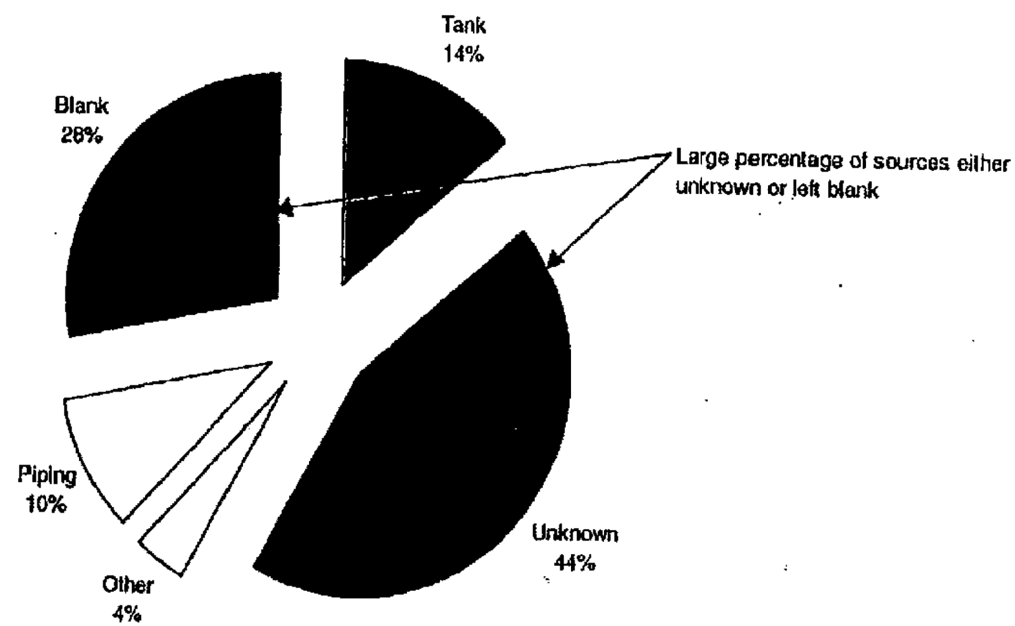
Relatively few studies have been able to quantify the likelihood or magnitude of releases from UST systems. This section discusses the only recent studies that have focused on these issues. Primary focus of the works discussed below was identifying the probability of release from a particular part of the UST system. The data are based on a large database that has information on leaks of systems pre- and post- 1998 upgraded/new systems. California Governor's Team 2 work is examining recent releases from "newer" sites, which was discussed earlier in Section III of this report.

A report entitled "Health & Environmental Assessment of MTBE" was recently written for the governor and legislature of the State of California, as sponsored by SB 521. Volume 4 of this report contains a chapter named "Leaking Underground Storage Tanks as Point Sources of MTBE to Ground water and Related MTBE-UST Compatibility Issues," by Couch and Young. This chapter discusses the results of an evaluation of data from a database obtained from the California State Water Resource Control Board (CASWRCB) called Leaking Underground Storage Tank Information System (LUSTIS) database. All reports filed between 6/1/96 and 12/17/97 were reviewed and evaluated for the tank age, release source, release discovery etc. The conclusion of this report states that, "Analysis...showed that a lower bound estimate of release incidence among upgraded USTs could be placed at 0.07% per year."

Additionally, Young has prepared another preliminary report looking at CASWRCB LUSTIS reports filed between 6/1/96 through 7/1/98. As shown in Figure V-2, Young's evaluation indicates that most of the time, the source of the leak is either left blank in the database or is unknown. However, there are still some cases where the tank, piping or another source was listed. Young further evaluated the characteristics of the leaking tanks and piping. This information is shown in Figure V-3 and V-4. As Figure V-3 indicates, the majority of the surveyed tanks are greater than 15 years old, bare steel, and the leaks were discovered during tank closure or removal. As shown in Figure V-4, the majority of the surveyed pipes were greater than 15 years old, constructed of bare steel, and only had single walls. As Young concludes in his preliminary report, "Although a substantial number of motor fuel releases from UST systems continue to be reported to the SWRCB, very few of these releases are occurring from systems that meet all of the applicable regulatory standards. The major environmental threat from USTs continues to be posed by substandard tank systems that must be upgraded under current regulatory guidelines." Young also states that, "Further investigation of the few cases identified in this study that appear to have been fully upgraded and yet had a product release" is needed.

Moreover, Young reports results of a field study "that relied upon local agency inspectors to collect the desired information when performing system inspections at tank closure, upgrade or any other time when the excavation was open for visible examination." Sources and their causes are shown in Figure V-5. Again, many times, the source is not identified (left blank) or unknown, but there were still several cases where the tank, the dispenser or the pipes were identified as the source. The majority of the causes are listed as blank or unknown, with corrosion, loose fitting, and overfill listed as the next highest causes. Characteristics of the sites studied still needs to be clarified.

Figure V-2: Preliminary Analysis of CA SWRCB's Leaking Underground Storage Tank Inventory System



Prelimary Data from Tom Young, UC-Davis

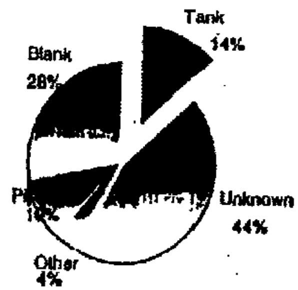
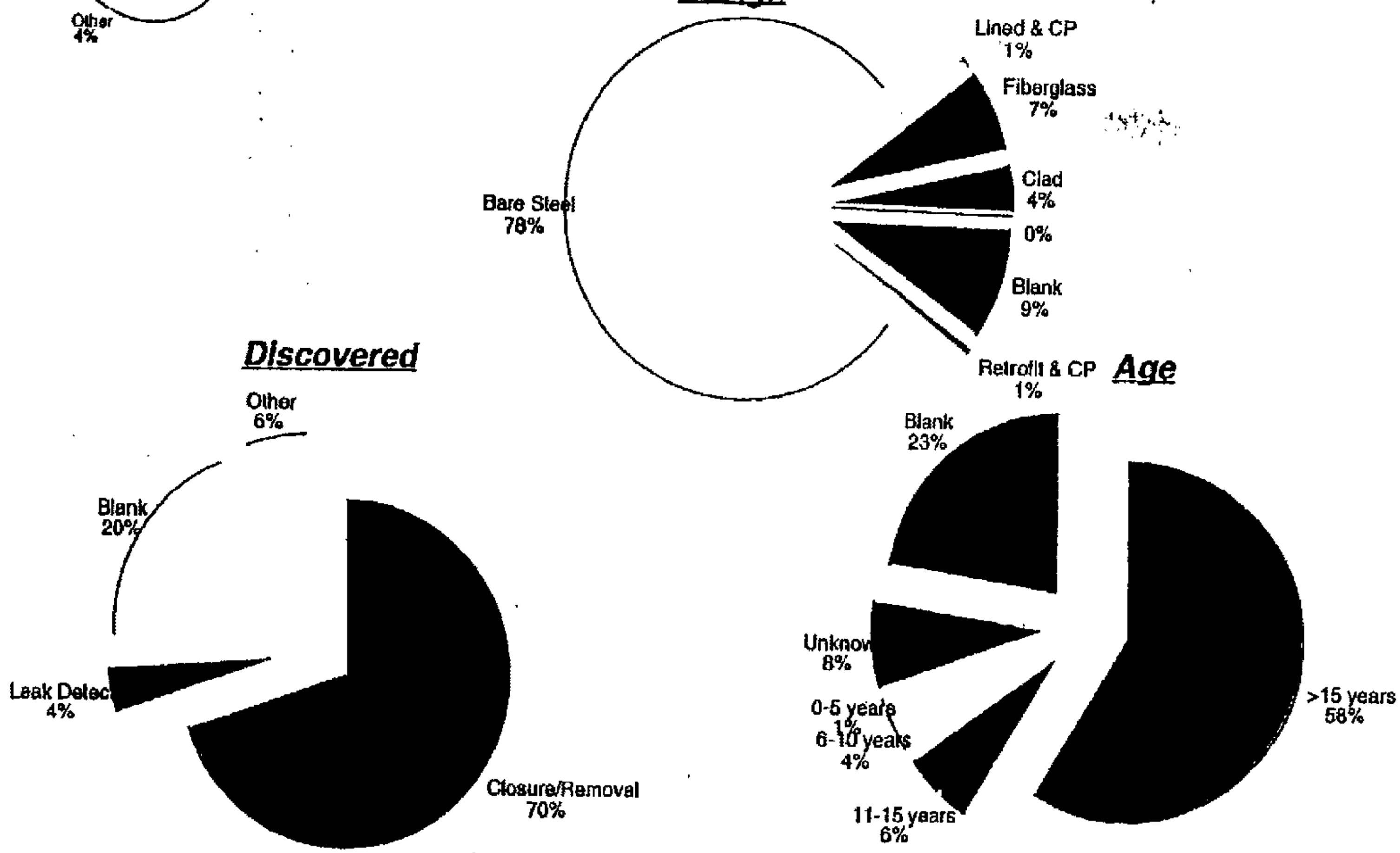


Figure V-3: Preliminary Analysis of CA SWRCB's Leaking Underground Storage Tank Inventory System

Details of Tanks Listed as Source



Prelimary Data from Tom Young, UC-Davis (12/98)

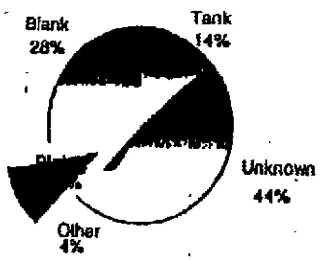
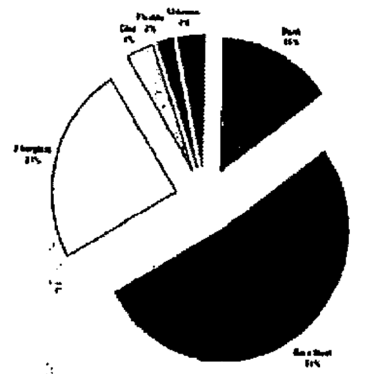


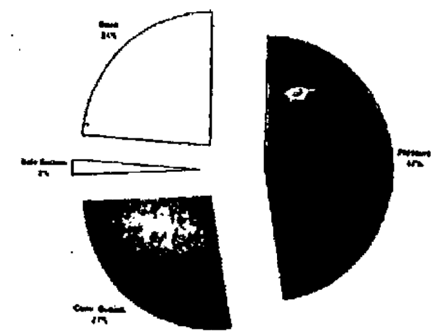
Figure V-4: Preliminary Analysis of CA SWRCB's Leaking Underground Storage Tank Inventory System

Details of Piping Listed as Source

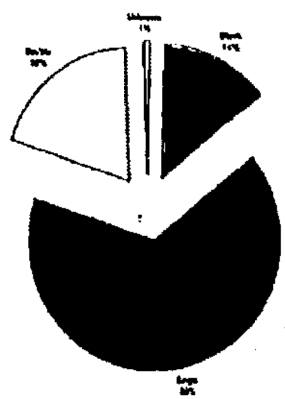
Piping Material



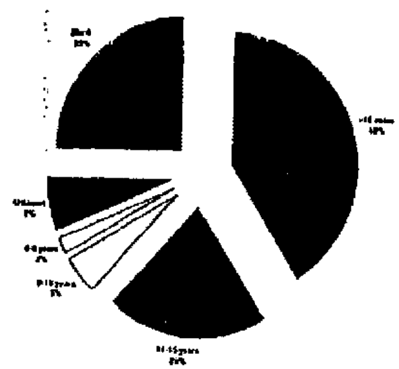
Pump System



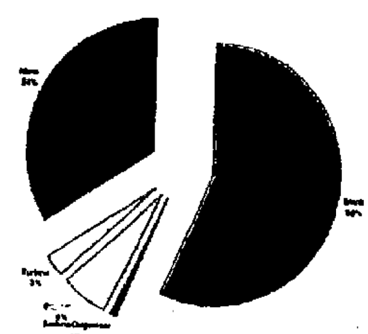
Piping Walls



Age



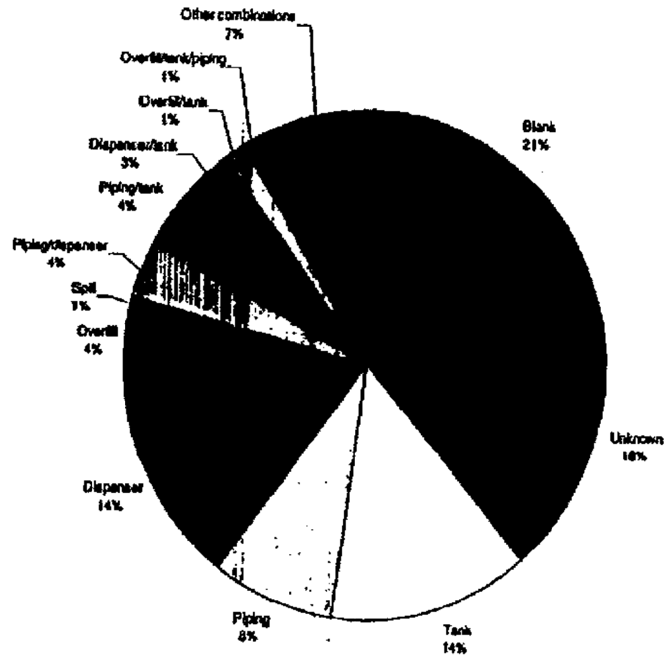
Containment



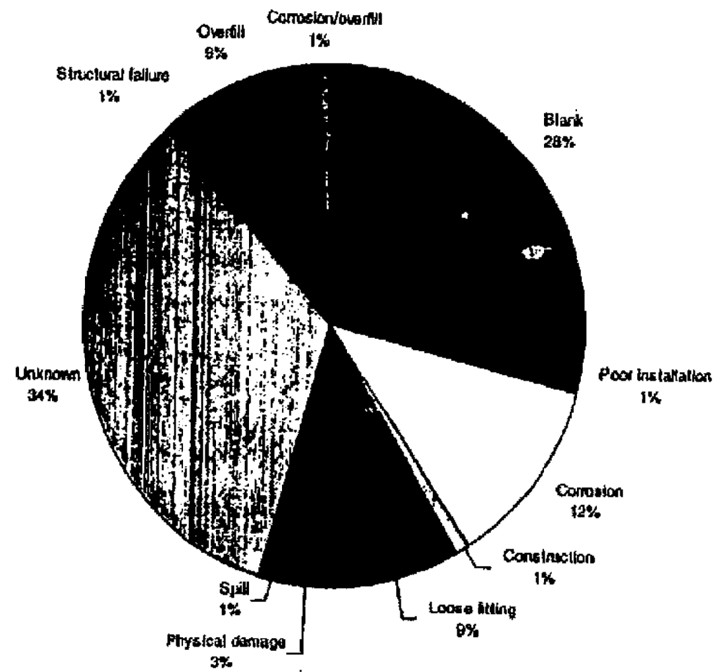
Prelimary Data from Tom Young, UC-Davis (12/98)

Figure V-5: Preliminary Analysis of Data Collected During Field Inspections of CA Sites

Source



Cause



Prelimary Data from Tom Young, UC-Davis (12/98)

c. Controllable and Non-Controllable Sources

In some cases, retail sites have control over potential leaks, and in other cases, the potential source is outside of their control. Table 4 lists the controllable and non-controllable sources.

Table 4: List of Controllable and Non-Controllable Sources

Controllable	Non-Controllable
Leaks found from testing - through increased frequency - enhanced record keeping Improved Housekeeping - while filling tanks - auto fueling (full service) Improved Quality Control during Construction - ensure "as-built" materials agree with design	Leaks from autos - during fueling - nearby accidents Leaks from equipment not owned by the Retail Site - hired landscapers who accidentally spill lawnmower fuel

d. Material Compatibility Issues

Davidson (1997, 1998) and Couch and Young (1998) recently conducted reviews of the available literature to assess the issue of MTBE and material compatibility. The reviews primarily focused on the materials that are typically found in UST systems and form the basis of much of what is summarized below. For additional detail, these studies and their references should be reviewed. Additional information on material compatibility issues will be provided in the report generated by California Governor's UST Panel Team 1. This report is expected to be available 1Q99.

Tanks and Piping

Metal compatibility with MTBE is not believed to be an issue for UST systems. Immersion tests on metal coupons have shown metals to be resistant to (up to 15 vol. %) MTBE-blended gasoline (Sun Refining, 1988). Tests measured weight changes in metal coupons over a period of approximately 1/2 year. Lang and Palmer (1989) concluded that MTBE was the least aggressive of four possible gasoline additives: methanol, ethanol, TBA, and MTBE; although no specific data was provided in support of this judgment.

Fiberglass compatibility with MTBE is not believed to be an issue for UST systems. Studies measuring volume changes and strength and hardness changes upon exposure to MTBE-blended gasoline show no significant adverse effects due to MTBE (Sun Refining, 1988; Douthit, et al., 1988; Davidson, 1998). No literature sources were found examining permeability testing pertaining specifically to MTBE-blended fuels and

fiberglass tanks or piping. However, Davidson (1998) discusses this issue, along with Owens-Corning's opinion, and concludes that MTBE, due to its chemical structure and size, would be unlikely to be readily permeable through fiberglass.

Fewer studies are available concerning the compatibility of flexible piping. Seven different piping systems were tested (either by the manufacturer or Underwriter's Laboratories) and approved their flexible piping for use with MTBE-blended fuels (CaSWRCB, 1997 - in Couch and Young, ICF, Inc., 1997). Manufacturer test methods used are not described.

Seals

Several elastomers and plastics have shown resistance to MTBE-blended gasoline in short-term exposure tests (Alexander, et al, 1994, Smith, 1995). However, some fluorine-containing elastomers have shown poorer performance in MTBE-blended gasoline (Davidson, 1998; Couch and Young, 1998). According to Boggs, 1997, "One short-term test (168 hours) that used several concentrations of MTBE showed swelling could occur with some elastomers at current gasoline mixture levels." In actual field cases, there have been no documented reports of UST system failing and causing a release because of exposure to MTBE-blended gasoline. However, this does not rule out the possibility of problems with existing tanks systems that are leaking slowly and have yet to excavated or examined.

While it is believed that Exxon is specifying the proper seal materials for its service station facilities, it is possible that improper seals are being mistakenly used at the time of construction. Unlike piping, it is very difficult to distinguish between different kinds of seals in the field and this could lead to the use of some incompatible materials. These could be easily confused with specified seal. This problem is not expected to be wide-spread. Careful post-failure analysis would be required to identify the extent of this problem.

Vapor Recovery Systems

Generally, compounds in the vapor-phase are not as aggressive to materials as they are in the liquid-phase. However, due to the higher vapor pressure of MTBE, it is commonly thought that vapors from MTBE-blended gasoline could become enriched in MTBE relative to the levels in liquid gasoline. While the constituents and thus the vapor pressure of gasoline can vary, calculations show that the concentration of MTBE vapors would not be present at a concentration higher than in the gasoline. If condensation of the vapor occurs in the vapor recovery system, MTBE would condense prior to other vapor components and, therefore, the resulting condensate would be enriched in MTBE relative to gasoline.

Because vapor recovery systems are not tested as regularly as piping and tanks, there is a greater chance of having an unidentified cracked connection or leaking seal that could

serve as the source of a release. In discussions with EUSA Marketing environmental staff, it was expressed that more attention should be given to this potential release source.

VI. Summary

A review of literature and applicable research on MTBE release source identification was completed, focusing on retail marketing facilities. Additionally, analysis of MTBE ground water contamination from selected EUSA service stations in New Jersey and California was performed. The data were found to fit within the range of similar MTBE data published in the literature by such organizations as Chevron, and the Lawrence Livermore National Laboratory. Unfortunately, these data were not sufficient to allow for identification of release sources. Several data gaps are identified for future followup analysis, and include: tank and line tightness test data; maintenance and construction data relevant to service stations with MTBE contamination; quarterly ground water monitoring data collection, and; more detailed data on site hydrogeology parameters to assist in determination of MTBE contamination concentrations and release sources.

Materials of construction used for equipment in contact with gasoline containing MTBE were reviewed, and were found to be compatible in most cases. There are some elastomers and plastics, however, that were identified as exhibiting poor compatibility with MTBE (e.g. fluorine containing elastomers). Vapor recovery systems are identified as an area of concern regarding potential material compatibility problems.

Potential release sources are identified and documented in the report, and include the following systems, activities, and equipment found at service stations:

<u>Auto Refueling</u>
- Repeated small releases
- Presence of cracked pavement

<u>UST Gasoline Delivery</u>
- Small releases from below grade connections
- Remote filling point line leaks

<u>UST System Releases</u>
- Piping Connections and seals
- Vapor recovery system
- Poor construction and equipment installation

Lastly, laboratory analytical data for MTBE contamination concentrations must be carefully evaluated due to the possibility of false positive results being produced when using EPA Method 8020. When samples analyzed contain significant levels of other gasoline constituents, confirmatory testing using EPA Method 8260 is recommended.

VII. Recommendations

Reflecting both industry and regulatory agency concerns with MTBE subsurface contamination, several significant ongoing MTBE source identification research projects have been identified in this report. Continued Exxon monitoring, review of, and/or participation in several of these projects is recommended. In so doing, EUSA can use the most current learnings from these projects and adapt applicable design, construction, and operation modifications that can further minimize potential MTBE contamination before it reaches soil and ground water. The research projects warranting continued EUSA attention, through leveraging of existing research or direct participation, include:

- Western States Petroleum Association MTBE Source Protection Research Partnership
- American Petroleum Institute Committees
  - Gasoline/MTBE Source Identification
  - Soil/Ground water Technical Group(MTBE Research)
- Petroleum Environmental Research Forum MTBE Source Identification and Prevention
- Santa Clara Valley (California) Water District MTBE UST Release Study
- US EPA MTBE Blue Ribbon Panel Research Group

Regarding EUSA site specific MTBE contamination data, additional data collection and analysis is recommended. These data include construction and maintenance file data for MTBE contaminated service stations, and all available quarterly soil and ground water monitoring data. The evaluation of these data should more definitively allow for correlation of MTBE releases with applicable sources. Additionally, review of data currently being collected from the EUSA New Jersey Service Station Stage II Vapor Testing Program should be conducted to further clarify relationships between identified MTBE contamination and likely system or equipment release sources.

If time and costs can be justified, consideration should be given to identifying a new EUSA service station champion site to conduct a comprehensive MTBE contamination monitoring program. Should this not prove to be feasible, involvement in a similar industry sponsored program may be worthwhile. This type of research project would focus on the identified potential release sources (e.g., vapor releases in UST systems), and greatly facilitate development of best practices to help prevent contamination from MTBE and other gasoline components.

Though not included in the scope of work for this project, addressing cleanup of existing MTBE contamination at retail sites should also be considered in future research work.

This work could include evaluating risk assessment methodologies for MTBE contamination, and identifying key mitigation and remediation technologies (and enhancements) for retail site cleanups.

VIII. Appendices

a. Literature Review Summaries

b. Exxon Retail Site Contamination Data Tables

c. UST Integrity Testing Summary

d. MTBE Property Information

a. *Literature Review Summaries*

General Reference	Category	Notes	Reference Informat'n
"An Evaluation of MTBE Impacts to California Groundwater Resources" June, 1998	Prevalence	Examination of 235 LUST sites in CA, found MTBE detections at 78% of these sites. Concentrations ranged from several ppb to ~ 100,000 ppb. For ~ 80% of 50 plumes, MTBE plumes (20 ppb) were equal to or smaller that Benzene plumes (1 ppb). Also discusses plume behavior over time and analytical issues (discussed separately below)	Happel, et al. Lawrence Livermore National Laboratory, UCRL-AR-130897, June 11, 1998
"An Evaluation of MTBE Impacts to California Groundwater Resources" June, 1998	Analytical	USEPA and ASTM methods tested - 8020A/21B (PIDs) is most commonly used method - has limitations, poor sensitivity at low amounts of gasoline, false-positives when w/ high concentration (>500 ppb TPH). Of non-oxygenated gasoline. In contrast, EPA 8260A (MS) and a modified version of ASTM Method D4815 (FID, test excludes BTEX) produced excellent results - these methods are recommended in cases w/ high regulatory impact. Indicates ~ 20 ppb may be the minimum suggested reporting limit in the presence of gasolines to minimize false positives.	Happel, et al. Lawrence Livermore National Laboratory, UCRL-AR-130897, June 11, 1998
"Evaluation of EPA & ASTM Methods for Analysis of Oxygenates in Groundwater", June, 1998	Analytical	Tests of EPA 8020A/21B, EPA 8260, and ASTM D4815 - determination of practical quantification limits, method detection limits, and linear ranges for a # of oxygenates, including MTBE.	Halden, et al. NGWA - The Southwest Focused Ground Water Conference: Discussing the Issue of MTBE and Perchlorate in Ground Water - '98.
"Occurrence and Behavior of MTBE in Ground Water", June 1998	Prevalence	700 Service Station Sites surveyed - MTBE at 80% of sites - 88% operating facilities, 74% at non-operating facilities.	Buscheck, et al. NGWA - The Southwest Focused Ground Water Conference: Discussing the Issue of MTBE and Perchlorate in Ground Water - '98.
"Environmental Fate and Behavior of MTBE", June 1998	Sources - General	Discussion of Environmental Behavior - High concentrations, particularly w/ BTEX - probably a pt. Source; low concentrations (<a few ppb) - likely non-point source - atm washout	Squillace, et al. NGWA - The Southwest Focused Ground Water Conference: Discussing the Issue of MTBE and Perchlorate in Ground Water - '98
"Santa Clara Valley Water District's Leaking UST Oversight Program 'MTBE Issues in Santa Clara County Water Supplies", June, 1998	Prevalence	Discussion of Prevalence in Santa Clara Valley - 811 total UST cases: 485 w/ gasoline, 414 monitoring for MTBE, 288 detect MTBE. 85%+ cases monitoring for MTBE - 70% of those detect it. Highest GW concentrations range evenly from a few ppb up to 400,000 ppb. 31% of operating UST sites have MTBE > 3500 ppb.	Crowley and Tulloch. NGWA - The Southwest Focused Ground Water Conference: Discussing the Issue of MTBE and Perchlorate in Ground Water - '98
"Santa Clara Valley Water District's Leaking UST Oversight Program 'MTBE Issues in Santa Clara County Water Supplies", June, 1998	Sources - UST	Tosco site - Santa Clara - Double walled '98 compliant tanks are not leaking, yet have a high MTBE concentration (up to 140,000 ppb) in the groundwater. There is no appreciable Benzene conc. - Theory - MTBE vapor release - Tosco unable to provide explanation for release. Similar problem (lower concentrations) for Chevron - believe the releases are from older tanks (new ones installed in '94).	Crowley and Tulloch. NGWA - The Southwest Focused Ground Water Conference: Discussing the Issue of MTBE and Perchlorate in Ground Water - '98

General Reference	Category	Notes	Reference Information
"Team 3 Leak Source Data Collection and Analysis Draft Report, Version 1, 11/17/98"	Sources - UST	On-going study at UC-Davis. Includes analysis of two data bases attempting to identify and quantify leak sources. Results illustrate a lack of enforcement of proper testing and poor reporting or difficulty in reporting of findings. Most releases only identified on tank closure or excavation.	*Young, T - UC-Davis Draft Report - For Internal Exxon Use Only, Released 11/98. Contact: tyoung@ucdavis.edu*
"Leaking Underground Storage Tanks (USTs) as Point Sources of MTBE to Groundwater and Related MTBE-UST compatibility Issues" -UC Davis Research Program - T. Young/ K. Couch	Sources - UST	*R&D Report addresses the probability of product releases from UST systems and also the compatibility of materials used in UST systems construction with MTBE. Review of studies indicates that no significant threat exists to UST systems from the concentrations of MTBE likely to be present in fuels. Most MTBE has been shown to be incompatible w/ some fluorinated elastomeric seals. However, the authors believe that further research is needed, particularly for metallic corrosion, fiberglass permeablity, and elastomer performance. Survey of six annual periods led to a prediction that 2-3% of tanks will/are leaking - < .1% for upgraded tanks (newer population).*	*UC-Davis Draft Report, Released 11/98. Contact: tyoung@ucdavis.edu, report from UCDavis website - http://tsrtp.ucdavis.edu/mtberpt/*
"Spatial and Temporal Variability of MTBE Plumes in Texas" - Oct. 1998	Prevalence	Survey of 609 LUST Sites. Most Sites (85%) have MTBE concentrations that exceed EPA advisory level (20 ppb). Maximum MTBE concentrations are more likely to be higher for sites having shallow depth to groundwater (<20 ft). MTBE plumes are, on average, 27 ft. longer than Benzene plumes. Report is very similar to LLNL CA study.	Mace, Report for API (API-GW-61), Contact: (512) 471-6246, Email: MACER@BEGV.BEG.UTEXAS.EDU, Oct. 1998
"Public Drinking Water Systems Impacted by MTBE Contamination"	Prevalence	Case studies regarding water supply wells being contaminated with MTBE from service stations - spills + LUSTs. Included is summary table of data gathered by various investigators and State Dept. of Health organizations (# wells tested, # contaminated, concentration range/max.)	Jim Davidson, Alpine Environmental Report - 970-224-4608
"Guidance on Analytical Methods for Oxygenates and Additives at Gasoline UST Sites" - CAL EPA - 5/98	Analytical	Data on "what's in gasoline?" from refiners plus guidance on analytical methods to be used for oxygenates/additives at gasoline/UST sites. EPA Method 8260 (GC-MS) is effective and the less expensive Method 8020 (GC-PID) can be used for MTBE under certain circumstances. False positives are common using 8020 on samples with high TPH. 8260 is recommended for preclosure and for investigation and monitoring if TPH is > 5 ppm. Other sampling recommendations are provided. Attachment from SHELL recommends having at least one confirmatory sample with 8260 when using 8020/21 for gw samples. For soils SHELL recommends Method 8260 - The PID used by 8020/21 is subject to interference from branched HCs, olefins and cyclic compounds in soil samples.	Letter to California EPA - San Francisco Bay Regional Water Quality Control Board, 5/98
USGS Laboratory Method for MTBE and other Fuel Oxygenates - Circa 1995/96	Analytical	Discussion of Laboratory work done to test a GC/MS method (comparable to EPA Method 542.2). Accuracy and Precision were shown to be very good. The method detection limit for MTBE concentrations is 0.06 ug/L and the method reporting limit is 0.20 ug/L. GC/MS method confirmed to be very reliable for detection of MTBE	USGS - Internal Report, circa 1995-96

General Reference	Category	Notes	Reference Information
"Comparison of EPA 8020 and EPA 8240 Analytical Results for MTBE in Ground Water Samples from LUFT Sites" - 8/96	Analytical	False positives reported by EPA 8020 only occurred in samples containing elevated levels of gasoline. False negatives did not occur. The overall occurrence of false positives by 8020 was low (4%). The 2 false positives were > 100 ug/L. Overestimation of MTBE concentration by 8020 may occur when gasoline concentrations are high and MTBE concentrations are low (20-170 ug/L) in gw samples. Recommendation: 8020 is OK - verification with 8240 or 8260 should be performed on at least one sample if MTBE is detected w/ 8020.	Happel, Lawrence Livermore National Laboratory, 8/96
Analysis Required for Oxygenate Compounds used in California Gasoline - EPA Method 8260 - California Regional Water Quality. Control Board - 7/97	Analytical	Recommendation/Requirement: In order to determine which oxygenated compound is present, water samples must be analyzed by EPA method 8260 and the presence or absence of the oxygenate reported.	California Regional Water Quality. Control Board - 7/97
Chemical Constituents of Gasoline - California Regional Water Quality. Control Board - 7/97	Prevalence	Letter from the board to oil companies requiring disclosure of gasoline constituents and suggested analytical methods. MTBE mentioned as being present at 70-80% of LUST sites in region (San Francisco).	California Regional Water Quality. Control Board - 7/97
Occurrence and Behavior of MTBE in Groundwater - Chevron - Buscheck, et al. - 11/97	Analytical	Earlier report on work discussed at NGWA Southwest Conf. '96. Reference to Happel '97 / LLNL report: no MTBE false positives for TPH < 1,000 ug/L (280 samples), for TPH > 1,000 ug/L 3% false positives where MTBE < 100 ug/L (33 samples) and 14% where MTBE was >100 ug/L (111 samples). Chevron data from No. California indicates higher rate of false positives and suggests that GC/MS is critical for TPH > 1000ug/L and MTBE ≤ 1,000ug/L (almost 1/2 of such samples generated false positives in Chevron analysis.	Proceedings, Petroleum Hydrocarbons and Organic Chemicals in Ground Water, NGWA/API, Nov. 12-14, 1997.
Acidification of Groundwater Samples for Sample Preservation and Questionable Effect on Determined MTBE Concentrations - Circa June '98	Analytical	Paper deals with the potential changes in MTBE groundwater concentrations due to sample preservation losses. Acid (pH<2) preservation can lead to hydrolysis of MTBE over time, thereby decreasing its concentration.	M. Wade, Wade Research, Inc.
State Summaries of Cleanup Standards - 11/97	Analytical	Tables summarize state action/cleanup standards for soil and groundwater, most include prescribed test method.	Judge, et al. Soil & Groundwater Cleanup, Nov. 1997 for Soils - May 1998 for Groundwater.

General Reference	Category	Notes	Reference Information
MTBE Compatibility with UST Systems - Davidson, 10/97	Compatibility	Good General Background - UST components, Improvements to USTs over the years, Source Pathways. MTBE-blended gasoline did not impact steel tanks, steel piping, or other metal components in gasoline distribution systems. All information indicates that MTBE is compatible with fiberglass tanks and piping - Fiberglass Manufacturers stand behind their warranties for tanks holding up to 20% MTBE. Most available (somewhat limited) testing of seals indicates compatibility with MTBE (at least up to 15% in gasoline). No scientific basis found to support claims of incompatibility with glues or vapor recovery systems. Further study of seal compatibility and vapor phase MTBE losses would be beneficial. Good Reference List.	Davidson, J, Alpine Environmental Report for WSPA - 970-224-4608, 10/97
Survey of Flexible Piping Systems - ICF Inc. 3/97	Compatibility	Discussion of seven flexible piping manufacturers who have tested their piping w/ MTBE - mostly UL or ULC testing - not much detail given.	ICF Inc. Fairfax, VA - Can download from EPA OUST webpage
The Impact of Gasoline/Oxygenate Releases to the Environment - A Review of the Literature - Texaco, 10/95	Analytical - General	Review of GC methods for oxygenates in Water and Gasoline - No real recommendations, Good General Background - Physiochemical Properties of MTBE, History, In-depth look at Fate and Transport + Remediation Issues.	D. Conrad and W. Deever, Texaco R&D Department
A Preliminary Assessment of the Occurrence and Possible Sources of MTBE in Groundwater of the United States, 1993-1994 - USGS, '95	Prevalence	Summary of occurrence of MTBE detection in groundwater. Includes a discussion of possible sources of MTBE to the environment. Possible point sources include leaking gas tanks, pipelines, landfills, dumps, spills, industry, underground injection, and refueling facilities. Cites lack of association with BTEX when detected - possible reasons - high MTBE concentration in gasoline, high solubility (40x more soluble than BTEX) - lack of sorption, and resistance to biodegradation. Non-point sources: atmospheric deposition and stormwater runoff.	Squillace, P.J., et al. USGS OFR 95-456
Occurrence of the Gasoline Oxygenate MTBE and BTEX Compounds in Urban Stormwater in the United States, 1991-95 - USGS, '96	Prevalence	Summary of occurrence of MTBE in Stormwater - 592 samples collected from 16 cities. MTBE was detected in 6.9% of the stormwater samples collected. When detected, concentrations ranged from 0.2 to 8.7 ug/L, with a median of 1.5 ug/L. The influence of land usage on the stormwater runoff is uncertain.	Delzer, G.C., et al., Water Resources Investigations Report, 96-4145.

General Reference	Category	Notes	Reference Information
Addendum #1 - New Information Regarding MTBE Compatibility with Underground Storage Tank Systems - Davidson - 1/98	Compatibility	MTBE compatibility with Fiberglass Tanks and Lines: Sun Oil (Douthit, '88) showed through a series of experiments that MTBE-blended gasoline caused slightly less volumetric change of fiberglass coupons than old base gasoline - slightly greater for pipe samples. Fluid Containment (Owens Corning Fiberglass, Tank Division) conducted a 84 month, long-term exposure test with 20% MTBE gasoline - MTBE acted no differently than gasoline - claim to have never had a problem in field with internal corrosion (250,000 tanks sold). Manufacturers believe MTBE's size should deter its permeation through fiberglass. Conflicting data discussed on effect of MTBE on elastomers - citation of one paper that concludes that even 5% MTBE can cause serious damage on some seals. Effects of MTBE vapor/condensate discussed - topic requires further study.	Davidson, James. Alpine Environmental, Inc. (970)224-4608 - Prepared for WSPA
Underground Storage Tank Management - A Practical Guide - Lexicon - 1998	Regulatory Guidance	TOC: 1. Regulatory Highlights, 2. Inventory Control, 3. Leak Detection Through Inventory Analysis, 4. Tank Closure, 5. Underground Tank Testing, 6. Monitoring and Detection, 7. Overfill and Transfer Protection, 8. Tank Design, 9. Secondary Containment, 10. Installation of Underground Tanks, 11. Maintenance and Retrofit, 12. Storing Hazardous Substances, 13. Remedial Action, 14. The Legal Aspects, 15. Financial Responsibility, 16. Tank Management Plan, 18. Upgrade Versus New Installation (more detail on selected chapters below)	Rizzo, et al. Underground Storage Tank Management - A Practical Guide - Lexicon, 1998
Underground Storage Tank Management - A Practical Guide - Chapter 1 - Lexicon - 1998	Regulatory Guidance	Regulatory highlights - monitoring requirements, includes permissible monitoring by "other methods that can detect a 0.2 gallon per hour leak rate or a release of 150 gallons within a month with a probability of detection (Pd) of 0.95 and a probability of false alarm (Pfa) or 0.05 or as approved by the local agency. Other options outlined include tank tightness testing that is capable of detecting 0.1 gallon per hour leak rate.	Rizzo, et al. Underground Storage Tank Management - A Practical Guide - Lexicon, 1998
Underground Storage Tank Management - A Practical Guide - Chapter 2,3 - Lexicon - 1998	Regulatory Guidance	Inventory Control Methods discussed along with their application to leak prediction.	Rizzo, et al. Underground Storage Tank Management - A Practical Guide - Lexicon, 1998
Underground Storage Tank Management - A Practical Guide - Chapter 5 - Lexicon - 1998	Regulatory Guidance	Underground Tank Testing - Goes over procedures and capabilities - 0.10 gallons per hour represents the realistic precision level at which currently available methods are capable of detecting leakage. NFPA standards reviewed.	Rizzo, et al. Underground Storage Tank Management - A Practical Guide - Lexicon, 1998
Underground Storage Tank Management - A Practical Guide - Chapter 8 - Lexicon - 1998	Regulatory Guidance	Overfill & Transfer Protection: "Perhaps one of the most underrated and overlooked sources of contamination is from spillage that takes place during the handling of liquid products." Overfill protection requirements of 40 CFR 280.20(c) outlined. Consideration of collection basins, dry-disconnect piping, etc.	Rizzo, et al. Underground Storage Tank Management - A Practical Guide - Lexicon, 1998

General Reference	Category	Notes	Reference Information
Underground Storage Tank Management - A Practical Guide - Chapter 10 - Lexicon - 1998	Regulatory Guidance	Installation of Underground Tanks - Critical Days in the Life of a Tank: Discussion of general damages that can occur as a result of improper installation procedures. Installation check lists provided. Tank installation instruction examples provided.	Rizzo, et al. Underground Storage Tank Management - A Practical Guide - Lexicon, 1998
Study Reports LUST Programs are Feeling the Effects of MTBE Releases - Hitzig, et al. - 1998	Prevalence	Article presents a survey of state LUST Programs. 20 states have one or more sites with only MTBE contamination (may be more than 300 of these "mysterious" sites around the country). No particular type of tank or piping appears associated with releases. List possible sources as: gasoline dumping (lawnmower filling), historic releases, leaking overfill catch basins, seepage into monitoring wells, leaks in vapor recovery units, or inaccurate results from tank and piping tightness testing. Survey results include a look at what soil and groundwater remediation technologies are working.	Hitzig, R., et al. Soil & Groundwater Cleanup. August/September 1998.
Ten Frequently Asked Questions about MTBE in Water - API Soil and Groundwater Research Bulletin - 11/97	Sources - UST	Concentrations of MTBE in groundwater greater than about 30 ug/L originate from point sources (LUSTs), whereas lower concentrations may originate from both point and non-point sources. Non-point sources can include atmospheric washout or stormwater that contains fuel residues from roads, parking lots, etc. Concentrations from these non-point sources are unlikely to exceed 2-20 ug/L.	API Soil & Groundwater Research Bulletin, No. 3. November, 1997.
Fate and Transport of MTBE - The Latest Data	Prevalence	Summary & Interpretation of USGS surveys. Discusses (lack of) cosolvency effect.	Davidson, Jim, Alpine Environmental, Inc. 1995 - Petroleum Hydrocarbons and Organic Chemicals in Groundwater; Prevention, Detection, and Remediation Conference.
Organizations Related to Underground Storage Tanks - USEPA Website (11/98)	General	Listing of numerous organizations relevant to USTs - Manufacturers, Government and Trade groups, etc.	www.epa.gov/swerust1/ resource/orgs.htm
Catalog of USEPA Materials on Underground Storage Tanks - EPA - 3/98	General	Listing of EPA publications, Videos, Software, and Internet sites related to USTs - Includes leak detection, closure, and installation guidance.	EPA 510-B-98-001, www.epa.gov/OUST
Don't Wait Until 1998 - USEPA - 4/94	General	General overview/requirement guidance concerning Spill, Overfill, and Corrosion Protection for USTs. Includes a listing of contact organization relevant to MTBE - 16 pages.	EPA 510-B-94-002
Chemical Summary for Methyl-tert-butyl-ether - USEPA - Office of Pollution Prevention and Toxics - 8/94	Chemical Data	Summary of Physical and Chemical properties of MTBE. Includes environmental fate, health effects, and data on production of MTBE.	EPA 749-F-94-017a, www.epa.gov/opptintr/chemfact/s_mtbe.txt

General Reference	Category	Notes	Reference Information
The Presence of MTBE and Other Gasoline Compounds in Maine's Drinking Water - A Preliminary Report - 10/98	Prevalence	Report presents the preliminary findings from a study of the statewide occurrence of MTBE and other gasoline constituents in Maine's drinking water. 951 household wells and other water supplies (springs, etc.) were tested along with 193 of 830 regulated non-transient public water supplies. Samples analyzed for MTBE and BTEX. 1.1% of sampled > 35 ppb. MTBE found in 16% of public water supply wells (always <35ppb). Proximity to USTs found NOT to be a factor associated with finding MTBE. Compares additional factors as well.	Maine Bureau of Health-Department of Human Services, Bureau of Waste Management & Remediation-DEP, Maine Geological Survey-Department of Conservation
Fuel Oxygenates and Water Quality: Current Understanding of Sources, Occurrence in Natural Waters, Environmental Behavior, Fate, and Significance - 10/96	General	Report covers several areas: General sources/occurrences - Air/Water/USTs/etc., Environmental Fate and Behavior of oxygenates, and remediation considerations. Includes some data on monitoring results from several states - # wells with MTBE/ # wells tested. Minimal establishment of specific causes for state findings of MTBE - some site general UST failure.	Prepared for Interagency Oxygenated Fuel Assessment, Coordinated by Office of Science and Technology Policy - J. Zogorski, USGS is the chair of committee
<u>L.U.S.T.LINE PERIODICAL REFERENCES</u>			
An Emphasis on LUP's - The Weak Spots in Piping - 12/87	Leaks	Discussion of the potential significance of poor piping installation. "Most tanks, nowadays, fail due to corrosion, while most piping fails due to improper installation." Discussion includes Unions, swing joints, Fiberglass-steel connections, Loose connections, and lack of testing. Limited hard data.	Marcel Moreau (petroleum storage specialist with E.C. Jordan, Maine), L.U.S.T.LINE, Bulletin 7, May 1988.
Several Articles - 02/90	Leaks	Series of articles address UST tests - needs, what to consider, etc.	L.U.S.T.LINE, Bulletin 12; Feb 1990.
The A to ZZZs of Pressurized Piping Leak Detection - 10/92	Leaks	Discussion of the requirements and capabilities of piping leak detection systems. Require ability to detect 3 gph leak in one hour - a continuous testing. Second requirement - Either a monthly test to detect 0.2 gph or 150 gallons/month or Annual line tightness testing detecting 0.1 gph. (95% detection, w/ < 5% false positives required).	Marcel Moreau (petroleum storage specialist with E.C. Jordan, Maine), L.U.S.T.LINE, Bulletin 17, Oct. 1992.
MTBE - Beware of the False Positive - 6/97	Analytical	Discussion of the various methods that can be used to test for MTBE: 8020, 8240 and 8260. 8020 (GC-PID) subject to false positives - Alkanes can elute close to MTBE if run-time of analysis is short. 8240 and 8260 needed to confirm MTBE presence - they utilize GC-MS.	Blayne Hartman, TEG, Inc. L.U.S.T.Line Bulletin 26, July 1997.
Piping's Progress - 11/97	Leaks	Follow up to 12/87 article on piping weak spots/leak possibilities. Addresses improvements made to piping in past decade. Article takes a new look at use of low-melting point materials, sloping of piping, and how deep should piping be buried (no answer on this one).	Marcel Moreau (petroleum storage specialist with E.C. Jordan, Maine), L.U.S.T.LINE, Bulletin 27, Nov. 1997.

General Reference	Category	Notes	Reference Information
New Testing Requirements will Help California Regional Water Quality Control Board Keep Tabs on Oxygenates - 11/97	General	Discussion of an excerpts from California water quality control board position on MTBE: Analytical Sampling, Compatibility issues mentioned	Gordon Lee Boggs, L.U.S.T.LINE, Bulletin 27, Nov. 1997.
Are Leak Detection Methods Effective in Finding Leaks in UST Systems - California Survey Uncovers Some Cold, Hard Facts - 2/98	Leaks	Summary of results from a survey of 345 California LUST cases. 84% of leaks were discovered via closure. 63% of sites lacked monitoring or at least documentation of monitoring. There were on 5% of the cases where leak detection methods discovered a leak. Of the 121 cases for which leak source info was known, 50% were tank leaks and 34% were piping leaks. Most of the leaking systems were single-walled USTs, 10-40 yrs old.	Shahla Dargahi Farahnak, CA Water Resources Control Board. L.U.S.T.LINE, Bulletin 28, Feb. 1998.
The Holes in Our UST Systems - 09/98	Leaks	Discussion of possible sources at UST locations: Spillage and hypotheses of interpreting leak discoveries.	Marcel Moreau, L.U.S.T.LINE, Bulletin 30, Sept. 1998.

Exxon Engineering Reference	Category	Notes
88MATL 087 - GRP Underground Tanks - Owens-Corning Fiberglass Visit - 2/9/88	Compatibility	Describes Visit to O-C production facility in Conroe, TX. Indicates O-C conducts extensive strength retention testing of glass reinforced plastic tanks, including test involving MTBE. The data is not released to public (its proprietary) but was done rather to satisfy their own lawyers (they offer a 30 yr. warranty).
EE.123E.91 - NonMetallic Materials - New Developments - 16th Edition - 12/91	Compatibility	Evaluation of Commercial Data concerning the effect on nonmetallics of gasoline containing ether or alcohol. Polymers and elastomers were evaluated based on their suitability in MTBE and alcohol gasoline blends. The following coatings and linings were recommended: amine cured epoxy systems, epoxy phenemics, and vinyl ester systems. Elastomer recommendations - Gaskets, O-rings, and Packing: Teflons and Kalrez; Hose Materials: Polyethylene is recommended by Goodyear, Dunlop, and Gates; Seal Materials: Choose based on above recommendations. Overall Elastomer recommendations for MTBE blends: the Teflons and perfluoroelastomers do very well. Urethane and polyethylene (x-linked) performed reasonably well. Tables of test data provided for variety of materials.
92MATL 060 - Nonmetallics Gasoline Exposure Tests - 5/92	Compatibility	Various metallics evaluated in Exxon Supreme gasoline, in some cases with 20% MTBE. These materials included nitrile rubber from Environ Products, Inc., O-rings and cork gaskets from Facet Quantek, and GRP for manholes from EBW, Inc. After 30 day exposure tests, it was determined that all the materials would be suitable for use in retail outlet detection facilities and containment/isolation systems. Tables describing changes to physical properties are included.
92MATL 084 - Nonmetallics - Gasoline Exposure Tests - 6/92	Compatibility	Summary of findings from 30 day exposure tests on Total Containment Materials: "Original", "New22", and "D Material". None of the materials was found to be acceptable. Substantial weight and volume change occurred for each material exposed to Exxon Supreme w/ 20% MTBE. Conclusion: Recommend use of Warco products (reviewed in May 92) over these products for retail outlets' secondary containment designs.
Effect of Future Gasoline Blends on Nonmetallic Materials - EE.1M.93 - 3/93	Compatibility	Discussion of laboratory immersion tests for gasoline dispensing hose linings from Goodyear and Dayco. These were found suitable for blends that include up to 20% MTBE. 30-40 Day exposure tests were performed. Storage tank lining investigations performed as well, by manufacturers themselves: Porter-International, Southern Coatings, Carboline Co., Sherwin-Williams (Cook), Devoe Coatings Co., and Valspar Co. (Mobil Chemical). At time of report, all coatings were undergoing 1-yr exposure tests. General/Preliminary results: Epoxy, epoxy-phenemics, epoxy novalas and vinyl esters are suitable as shell and bottom linings. Iso-polyesters should not be used. Reference made to Exxon Marketing Dept. undertaking an independent test program which showed similar results.
Nonmetallic Materials - New Developments 17th Edition - EE.65E.92 - 7/92	Compatibility	Summary of two 1992 symposiums: International AST Symposium and National Association of Corrosion Engineers Symposium. Results by other companies confirm ERE test results for dispensing hoses.

Exxon Engineering Reference	Category	Notes
EE.2M.85 - Evaluation of Floating Roof Tanks and IFR Tank Seals in MTBE Gasoline Blends - 2/96	Compatibility	Report consolidates the industry's experience with resilient tank seals in MTBE containing gasoline service and specifically identifies elastomers and polymers suitable for neat MTBE service and for gasoline containing up to 20% MTBE. Teflon and Kalrez are recommended for use in MTBE at all concentrations. For gasoline with up to 20% MTBE, Viton GF, and highly saturated nitrile (HSN) have been identified as suitable floating roof tank seal material.

b. Exxon Retail Site Contamination Data Tables

NJ SERVICE STATIONS (Data from sites with at least one MTBE hit over 10,000 ppb - out of 215 sites with environmental presence)

Case #	Consult	City	Max. MTBE (ppb)	BTEX	Date	Distance to tanks (ft)	Depth to GW (ft)	Max. BTEX (ppb)	Date	Distance to tanks (ft)	Depth to GW (ft)	Release Date	Tank/Line Testing	Stage II Test	Remote fill	NAPL Thickness (ft)	NAPL near MTBE	NOTES
3-0001	GSC	Bound Brook	70,000	77	2/4/97	20-30?	7.0-9.0	28200	12/5/85	?	10.0-11.0		93, 95, etc.	Jan-98		0.03	no	BTEX: 77 ppb, TBA: 75,000 ppb at MTBE high conc., MTBE < ~ 1000 in most other locations, some ND
3-0021	Handex	Roselle	52,000	4,500	11/6/97	16	17.6	~4500	11/6/97	15	17.6		Jun-98	Jun-98		0.02-0.1	50 ft	MTBE > 10,000 in numerous locations
3-0088	GES	Trenton	72,000	38,000	4/17/91	50	5.1	38000	4/17/91	50	5.1		Oct-98					MTBE > 10,000 in another well, others <5,000
3-8195	GES	Ship Bottom	54,000	1,100	11/4/97	30-40	2.2	28000	2/13/91	?	2.2							BTEX: 1,100 ppb at MTBE peak conc.
3-8351	GSO	Absecon	33,000	30,000	4/19/96	80-90	5.2	30,000 - 60,000	4/19/96 - 5/18/84	80-90	5.2 - 5.6							MTBE < 7200 in all other locations
3-8782	Handex	Stratford	110,000 D	25000	11/5/90	25	9.8	00,000 ppm	8/8/85	60-70								BTEX: 5-25,000 ppb at MTBE peak conc.; MTBE < 30,000 ppb all other samples
3-0203	GES	Englewood	20-25,000		'96-'98	40, 120	8, 9.6	20-60,000		100-150	2, 7							Two wells high indicated high MTBE
3-0252	Handex	Fort Lee	130,000	15,500	8/2/89	50-70	3.9	87,000	6/27/86	60	8.3					0.02-0.55		BTEX: 18,800 ppb at MTBE peak conc ; MTBE ranges from 10-25,000 ppb in several other samples/locations, somewhat higer readings near remote fill. NAPL readings inconsistent
3-0887	Handex	Chatham	40,000	27,180	1/30/95	30		55,900	4/29/98	30						0.1-0.8	20-40 ft	MTBE < 15,000 at other locations
3-2002	Handex	Glen Rock	210,000	600	11/6/97	60-70		20,000	11/6/97	20-30								BTEX: 600 ppb at MTBE peak conc.; Two different tank fields exist - high BTEX close to old tanks
3-8116	Land Tech	Wayne	578,000	38,000	5/22/95		10	36,000	5/22/95		10					?	same well	One well very high, others either very low or about 5-10,000 ppb MTBE
3-2110	GSS	Colonia	18,000	1,153	5/20/97		6	15,000	5/20/97		5.5							BTEX and MTBE peaks in wells about 30 ft apart
3-2246	Handex	Englewood - Well 2	325,000	17,190	3/28/96	20	6.5(5-10)	17,190	3/28/96	20	6.5(5-10)							
3-2245	Handex	Englewood - Well 3	183,000	45,790	5/8/91	30	8.7(6-9)	45,790	5/5/91	30	8.7(6-9)						not in well	Substantial MTBE contamination - wells are direcly down gradient from Tanks and/or pump island.
3-2271	Handex	Edison - Well 2	190,000-270,000	47200 - 8740	11/6/1996 - 8/9/98	10		47,200 - 8740	11/6/1996 - 8/9/96	10						0.01-.3	same well	NAPL showed up after peaks
3-2271	Handex	Edison - Well 6	340,000 - 120,000	3250 - 6230	11/6/1996 - 8/9/96	20		3250 - 6230	11/6/1996 - 8/9/96	20								High levels of TBA also detected (50 - 60,000)
3-8613	GES	Morganville	241,000	3,021	8/21/92	40	18.8	32,400	9/10/97	40	16.6							8 of 11 wells have MTBE >1000ppb, most much higher.
3-8510	Handex	Bayonne	1,040,000	159,730	8/8/95	90		159,730	8/8/95	90								BTEX max in same well as MTBE max, much later in time. Well directly down gradient from tanks
3-2588	Land Tech	Bayonne	80,000	27	4/11/96	40	7.45	0 - 27	4/11/96	40	7.45					0.01	same well	NAPL detected in well 3 yrs earlier, 10 of 13 wells with MTBE > 15,000, NAPL seen in 1/2 of wells in '92
3-2588	GSC?	Marcerville	30,000	116	8/15/96	60	1.2	504	4/23/94	25	3.6	9/1/1988						VERY low/ND BTEX across site, MTBE spike cross-gradient from tanks, downgradient from islands
																		BTEX: 115ppb at MTBE peak, several notes with repon, faulty leak detect. System - vapor return loose at tank field

EXLIGU 07302

Case #	Consult	City	Max. MTBE (ppb)	BTEX	Date	Distance to tanks (ft)	Depth to GW (ft)	Max. BTEX (ppb)	Date	Distance to tanks (ft)	Depth to GW (ft)	Release Date	Tank/Line Testing	Stage II Test	Remote fills	NAPL Thickness (ft)	NAPL near MTBE	NOTES
3-4139	Handex	Summit	100,000	5,280	4/8/98	ND	42	22,300	1/17/97	200+	41							Flat water table, MTBE spike in well near garage, not tanks (deep screened portion of well - lower aquifer). BTEX: 5280ppb at MTBE peak. 5 of 10 wells with MTBE > 1000 ppb. BTEX peak appears to be someone else's.
3-4188	Handex	Denville	48,000	13,000	8/1/91	30		13,000	8/1/91	30								MTBE/BTEX peaks - directly down gradient of tanks/islands. MTBE > 1000ppb in 6 of 10 wells
3-4341	Handex	Bayonne	85,000 (d)	25000	4/10/95	10		25,000	4/10/95	10								5 of 6 wells with MTBE > 1000ppb
3-4485	Land Tech	East Hanover	155,000	23,050	8/18/92	80	19.4	3,700,000	10/21/96	120	18.3					0-0.21	same well	MTBE peak downgradient of tanks and former islands. BTEX peak downgradient of garage. NAPL found periodically in 2 of 6 wells.
3-4785	GES	Fort Lee	220,000	9,000	12/18/95	30	8.8	9,000	12/18/95	30	8.8							Ignored a 260,000+ BTEX reading - anomaly. Peak well is cross-gradient from tanks, downgradient from islands. 8 of 8 wells with >1000ppb MTBE
3-6427	GES	Fort Lee	65,300	5,000	3/8/93	10	9	25,000	6/21/91	15	6							BTEX: ~5,000ppb at MTBE peak. MTBE peak directly down-gradient from tanks.
3-5598	Land Tech	Fairlawn	170,000	27,700	9/28/98	10	10	96,500	10/20/89	10	12.6					0.01 (.1)	no well (oil	BTEX: 27,700 ppb at time of MTBE peak, well very close to tank field. MTBE/BTEX peaks in same well. 5 of 13 wells with MTBE>1,000
3-8177	Handex	Elizabeth	85,000	28,600	10/24/91	10	5.6	28,500	10/24/91	10	5.6							Well adjacent to tanks
			150,000	1,100	6/17/98	50	7	1100	5/17/98	50	7		6/4/98	Yes, passed		film	same well	Well directly downgradient from tanks, one BTEX reading up to 600,000 (est.) in this well. Testing results attached to report, passed tank/line tightness and SII tests - *Supreme line leak detector failed test.*
3-8181	Land Tech	Elizabeth	15,000	1,422	4/21/97	15		1422	4/21/97	15								Only one sampling round of data. Another well picked up 15,000ppb MTBE w/ ND BTEX
3-8288	Handex	Summit	31,000 - 360,000e	8500 (ND)	9/26/96	10		8500 (ND)	9/26/96	10			9/28/98	Partial, failed		yes	same well	NAPL in 3 of 13 wells, no thickness given. BTEX generally low relative to MTBE. Vapor recovery system failed pressure decay test, fiberglass connection not holding, problem fixed.
3-8618	Land Tech	Fanwood	74,000	3,710	2/24/98	15		3710	2/24/98	15			9/28/98	Yes, Passed				MTBE/BTEX peak downgradient from tanks. Only one sampling round available
3-7851	Handex	Colts Neck	190,000	1,856	12/3/96	40		13,080	3/31/95	70						yes	same well	BTEX: 1856ppb at MTBE peak, NAPL previously detected in same well. MTBE>1000 ppb in 3 of 10 wells; MTBE and BTEX peaks downgradient from pumps/tank field
3-8398	Handex	Jersey City	310,000	7,230	3/7/97	15		15,730	11/13/91	15								BTEX: 7,230ppb at MTBE peak, both peaks in same well - well directly downgradient from tanks; all 4 wells >1000ppb MTBE
3-8576	GSO	Howell	45,000	3,850	8/15/97	5	8.4	32,050	6/1/94	6 (pumps)	6	Jul-98				yes	no	BTEX: 3850ppb at MTBE peak, MTBE peak next to tanks, BTEX peak next to pumps; 7 of 10 wells > 1000ppb; product leak discovered in '98

EXLIGU 07303

Case #	Consult	City	Max. MTBE (ppb)	BTEX	Date	Distance to tanks (ft)	Depth to GW (ft)	Max. BTEX (ppb)	Date	Distance to tanks (ft)	Depth to GW (ft)	Release Date	Tank/Line Testing	Stage II Test	Remote fills	NAPL Thickness (ft)	NAPL near MTBE	NOTES
3-8856	Handex	Westfield	300,000	ND	12/9/93	10		600	3/3/95	30			8/93 - tanks pass, 8/97 & 8/98 - tank/lines pass	8/1/1998 - pass				BTEX: ND at MTBE peak, very low BTEX across entire site, 2 wells with high MTBE, MTBE near tanks(upgradient), BTEX downgradient
3-8869	Handex	New Brunswick	48,000	17,000	8/1/97	45		35,200	1/27/82	45								BTEX: 17,000ppb at MTBE peak, 6 of 10 wells MTBE>1000ppb; Peaks in the same well, downgradient from tanks
3-3468	Handex	Whitehouse	65,000	218	5/3/96	60	8.6	4,590	5/3/96	19								BTEX: 218ppb at MTBE peak, 6 of 11 wells with MTBE>1000ppb, BTEX relatively low across site
3-8792	Handex	Stratford	110,000	5,600	11/5/90	18		23,900	5/3/91	85								BTEX: 5,600ppb at MTBE peak, MTBE/BTEX peaks in the same well, 3 of 8 wells have MTBE>10000ppb, BTEX > 9000ppb, peaks in well downgradient from Tank field

REDACTED

EXLIGU 07305

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c. UST Integrity Testing Summary

Testing of UST Systems

Several methods exist for testing the integrity of UST and these can essentially be broken down into four categories (Moreau 1990):

- External: soil vapor and groundwater monitoring
- Internal: automatic tank gauging, inventory plus tightness testing, and manual tank gauging
- Interstitial: between the walls of a double-contained system
- Piping: (monthly) monitoring, (tri-annual) testing of check valve location for suction, line leak detector plus (monthly) monitoring or (annual) tightness testing for pressurized piping

While there are numerous leak tests for UST systems and the need for such tests is unquestionable, there is a lack of documented evidence regarding the efficacy of these tests in preventing releases to the environment (Young 1998). Young examined data from over a thousand UST sites and had difficulty assessing the efficacy of the various leak tests due to the inconsistency of testing, possibly a result of inconsistent enforcement of testing. Releases from USTs are most often discovered as a result of tank closure, with fewer than 10% of releases were discovered as a result of tank or line testing (Young 1998, Farahnak 1998)

Furthermore, if a UST system passes proper tank and line leak testing, the potential for impact on the environment still exists. While federal law stipulates that no release is acceptable, there is an understanding that test methods have detection limits below which they either can not detect a leak or are highly inaccurate. The following table summarizes the U.S. requirements for UST system testing (from CFR 40, Part 280):

System Component	Test Method	Test Applicability	Test Frequency	Test Criteria
Tank	Inventory Control		Daily records/ Monthly ck	1.0% of flow-through + 130 gallons/mo.
	Tank tightness testing		Depends on tank age, etc. See CFR 40, Part 280	0.1 gal/hr
	Auto. Tank gauging	Must be performed with Inventory Control	30 days	0.2 gal/hr
	Vapor Monitoring*	Dependent on soil conditions	30 days	Detect leak within 30 days
	Groundwater Monitoring*	Dependent on groundwater conditions	30 days	Detect leak within 30 days
	Interstitial Monitoring*	Double walled tanks, tanks with secondary barrier, or tanks with internally fitted liner	30 days	Detect leak within 30 days
	Any other method*		30 days	0.2 gal/hr or 150 gal w/in one month w/ probability of detection of 0.95 and a probability of false alarm of 0.05
Piping	Auto line leak detectors	Pressurized piping	Continuous, Annual test of detector is required	3 gal/hr at 10 psi within one hour
	Line tightness testing	Pressurized piping Suction piping	Annual 3 years	0.1 gal/hr at 1.5 times the operating pressure
	Any tank method denoted with a *	Same as for tanks	30 days	varies

Most commonly, tanks are subject to inventory control and tank tightness testing and piping is subject to auto line leak detection and line tightness testing. The test tolerances/requirements of these procedures are significant. For example, a UST system could pass both the line and tank tests and still be releasing up to 72 gal/month from the tank and/or the piping. The significance of such a release is realized by noting the consequence of even a very small release as shown in the attached figure.

d. MTBE Property Information

PHYSICAL AND CHEMICAL PROPERTIES

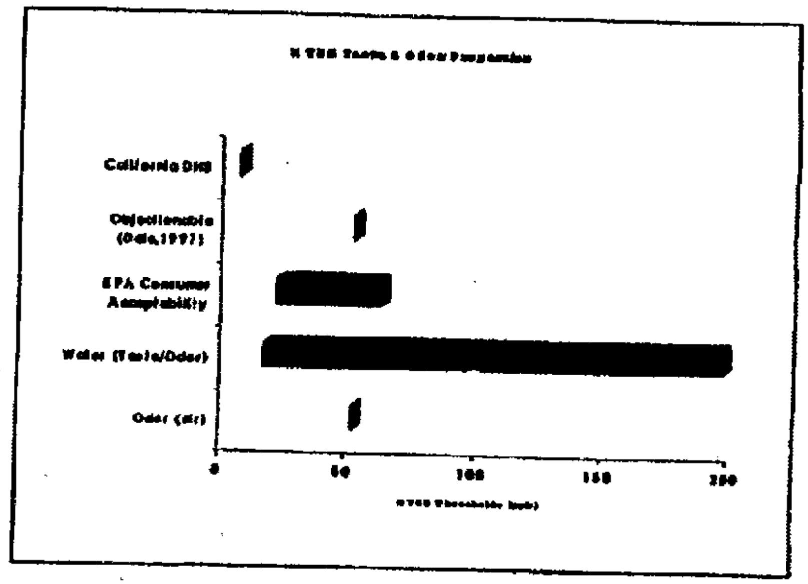
PROPERTY	MTBE	Benzene	Ethyl Benzene	Toluene	Xylene
CAS No.	1634-04-4	71-43-2	100-41-4	108-88-3	1330-20-7
Approx. Volume % in Gasoline	10-15	0.7 - 1.7	0.0 - 1.7	4.0 - 5.5	6.1 - 9.6
Chemical Formula	$C_5H_{12}O$	C_6H_6	$C_6H_5C_2H_5$	C_7H_8	$C_6H_4(CH_3)_2$
Molecular Weight	88.15	78.11	106.18	92.13	106.16
Melting Point	-109C	5.5C	-95.01C	-95C	-47.4-14C
Boiling Point	55.2C	80.1C	136.25C	110.6C	137-140C
Water Solubility (pure phase)	51260 mg/L at 25C	1780 mg/l at 25C	152 mg/l @ 25C	515 mg/l @ 20C	198 mg/l @ 20C
Water Solubility (effective)	~ 5000 mg/L	~ 13.50 mg/L	n/a	~ 28 mg/L	~ 19 mg/L
Density	d20/4, 0.7404 g/mL	d15/4, 0.8787 g/ml	d25/25, 0.866	d20/4, 0.866	d20/4, 0.866
KOC	11.0-12.3 ml/g	83 ml/g	1100 ml/g	300 ml/g	240 ml/g
Log KOW	1.24	2.12	3.15	2.73	3.26
Vapor Pressure	245 mmHg @ 25C	95.2 mmHg @ 25C	7.0 mmHg @ 20C	22.0 mmHg @ 20C	10.0 mmHg @ 20C
Reactivity					
Flash Point	-28C	-11C	18C	4.4C	29C
Henry's Law Constant @ 25C	5.5 x 10-4 atm m^3/mol	5.7 x 10-3 atm m^3/mol	8.5 x 10-3 atm m^3/mol	6.74 x 10-3 atm m^3/mol	7.04 x 10-3 atm m^3/mol
1st Order Bio-Decay Rate	0.0-0.0010 day^{-1}	0.002 day^{-1}	0.0028 day^{-1}	0.0022 day^{-1}	0.0026 day^{-1}
Fish Bioconcentration Factor	<2 (measured); <4 (estimated)	5.2 L/kg	37.5 L/kg	10.7 L/kg	
Odor Threshold	0.05 - 0.13 ppm	61 ppm		1.6 - 2.9 ppm	20 ppm
Drinking Water Standard					
CA	20 ppb???	0.7 ppb	680 ppb	100 ppb	1750 ppb
NJ	70 ppb	1.0 ppb	700 ppb	1000 ppb	1000 ppb
TLV-TWA	40 ppm / 144 mg/m3	0.5ppm / 1.6 mg/m3	100ppm / 434 mg/m3	50ppm / 188 mg/m3	100ppm / 434 mg/m3

MTBE CONCENTRATIONS MEASURED IN GROUNDWATER NEAR MTBE-BLENDED GASOLINE SPILLS

REFERENCE	NUMBER OF WELLS WITH MTBE	RANGE OF MTBE DETECTED (µg/L)
WILLIAMS (1998)	4,000	0.3 - 770,000
DAVIDSON (1995)	300	1 - 200,000
SQUILLACE, ET AL. (1995)	63	0.2 - 23,000
LUHRS & PYOTT (1992)	35	7 - 26,000
MALLEY, ET AL. (1993)	10	11 - 987
GARRETT, ET AL. (1986)	8	15 - 236,250
LANDMEYER, ET AL. (1997)	7	22 - 251,000

TASTE & ODOR PROPERTIES

- Detection Thresholds Quite Variable
- Waste (taste/odor) 15-180 ppb
- EPA Consumer Acceptability: 20-40 ppb
- Detectable at 15 ppb, Objectable at 50 ppb (So. CA Water District, 1997)
- California DHS 5 ppb



(Data collected by ARCO Corporate Health and Safety 12/98)